Volume 72 | June, 1958 | $4.00 a Year
Number 2 | Pages 81-220 | $1.25 a Number

Journal of the New England Water Works Association

ISSUED QUARTERLY
March, June, September and December

Published by
NEW ENGLAND WATER WORKS ASSOCIATION
73 Tremont Street, Boston 8, Massachusetts

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New England Water Works Association
1957-1958

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GEORGE C. HOUSER, 220 Clyde Street, Brookline 67, Massachusetts.

THE Association was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of over 1000 men. Its membership is divided into six classes, viz.:

A Member shall be an officer or employee of a public or private water works, an engineer, chemist or other person qualified to aid or interested in the advancement of knowledge relative to water works.

An Honorary Member shall be a person of acknowledged eminence in some branch of water supply or of engineering.

A Junior shall be not less than eighteen years nor more than twenty-five years of age, a student or connected with water supply work.

An Associate shall be either a person, firm or corporation engaged in manufacturing or furnishing materials or supplies for the construction or maintenance of water works.

A Corporate Member shall be either a Water Board, Commission, Company or Municipal Corporation.

The initiation fees and annual dues are as follows:

	Initiation Fees		*Annual Dues*
Members	$ 5.00	Members	$ 5.00
Juniors	1.00	Juniors	1.00
Associates	10.00	Associates	25.00
Corporate Members	10.00	Corporate Members	15.00

This Association has at least eight regular meetings each year, of which five are held in Boston, one in northern New England, one in southern New England, and one, the annual convention, held in September or October on such date as the Executive Committee may designate.

Low cost operation

Whether it be shining shoes, or a multi-million dollar industry, operational costs can spell the difference between success and failure. That is why so many government agencies, municipalities, private water companies, and industries have turned to LOCK JOINT CONCRETE PRESSURE PIPE.

The dense walls of Lock Joint Concrete Pressure Pipe resist electrolysis and soil corrosion. They also protect steel reinforcing of such conservative stress design that danger of bursting is virtually negligible. Result: replacement or even repair is a rarity, and danger of sudden failure which often entails extensive damage is held to a minimum.

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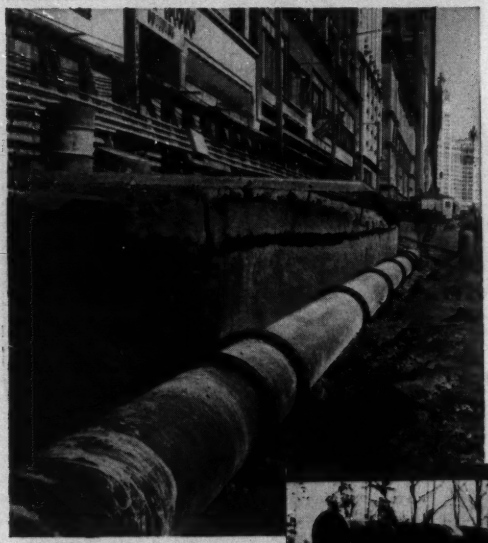
Sales Offices: Chicago, Ill. • Columbia, S. C. • Denver, Col. • Detroit, Mich. • Hartford, Conn. • Kansas City, Mo. • Perryman, Md.

Pressure • Water • Sewer • REINFORCED CONCRETE PIPE • Culvert • Subaqueous

WHATEVER THE SITE



Chicago, Ill.—Installing 24" Mechanical Joint cast iron pipe for water line rerouted due to construction of underground garage beneath Michigan Avenue.

Hickory, N. C.—High beam strength of Cast Iron Pipe makes it particularly adaptable to this type of construction on outfall sewer.

MODERNIZED **cast iron**

OR SITUATION...

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WHAT'S YOUR PROBLEM?

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6 reasons

why Cast Iron Pipe

is #1 choice of U. S. A.

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Dependability, long life are built into every rugged length of cast iron pipe. Dependability *proved*, not merely promised.

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Thos. F. Wolfe, Managing Director
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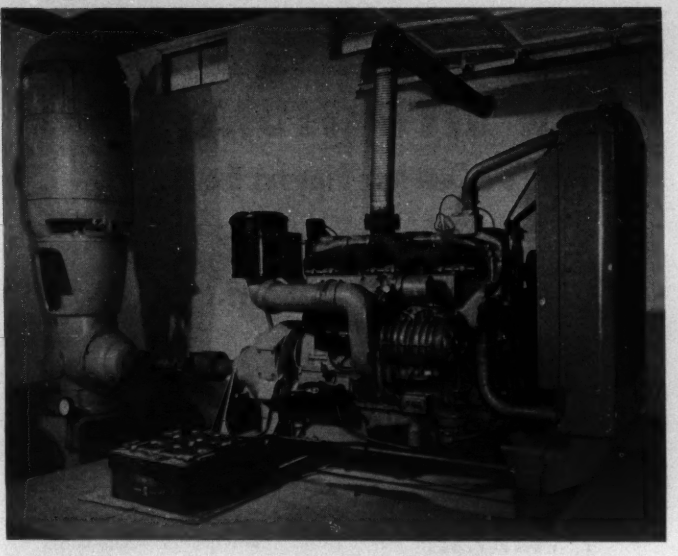
pipe FOR MODERN WATER WORKS



Diesel Engine Driven Pump Unit at Westfield Pumping Station, Westfield, Massachusetts

Designed and engineered by Mr. Don Weinle, City Engineer, the new Westfield Pumping Station includes a Cummins Model HRS engine, driving a Worthington vertical turbine pump through a U. S. Motor right angle drive as stand-by for electric power. Capacity is in excess of 2,000,000 gallons per day.

The new equipment was installed in November, 1957.

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I can show you easily and quickly with this scale model. See? When a Mathews is broken by a skidding automobile, you can slip in a new barrel in a matter of minutes, *and without excavating.* It's a real safety feature for the community—allows only momentary interruption of neighborhood fire protection.

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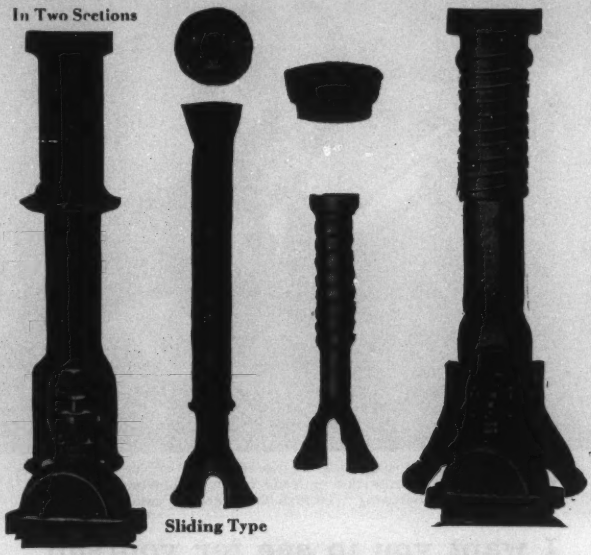

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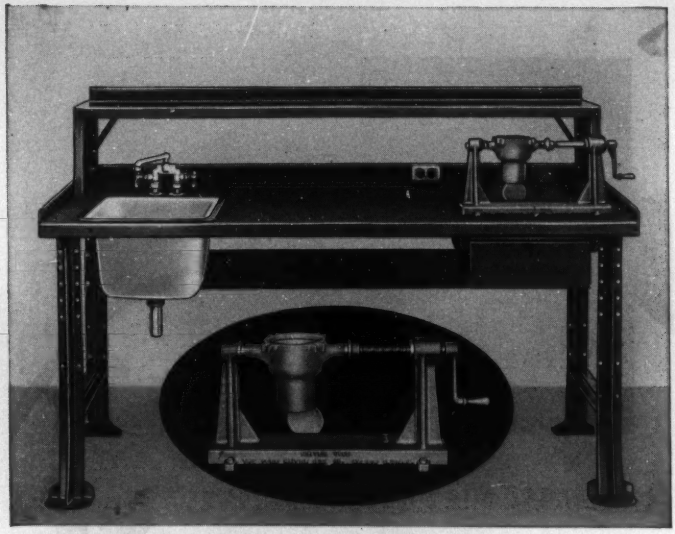

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Complete with Vise and Sink

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No. 56.

Here is a repair bench designed specifically for the water meter shop. A 34" x 72" working top supports a 15" acid resisting sink, a meter vise that holds meters from ⅝" to 1" in size and a tool drawer. Above the bench is a shelf. Bench may be equipped with pressed wood top, two drawers or two shelves if desired. Electrical and air hose connections are standard equipment. Complete information gladly supplied.

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FOR BETTER WATER SERVICES

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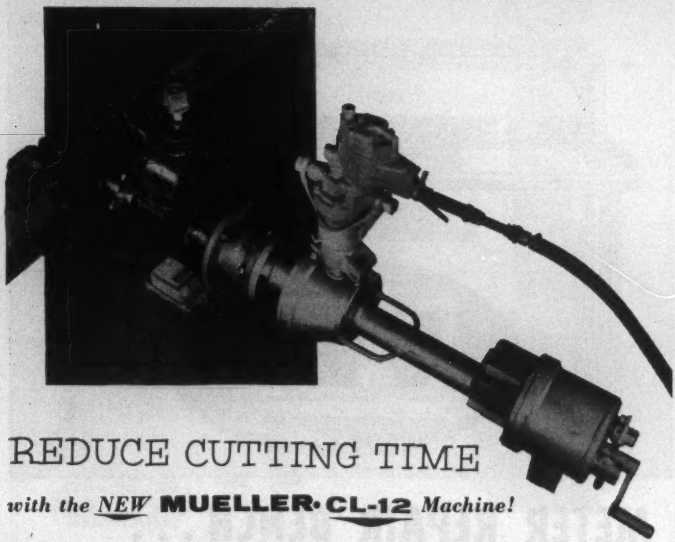

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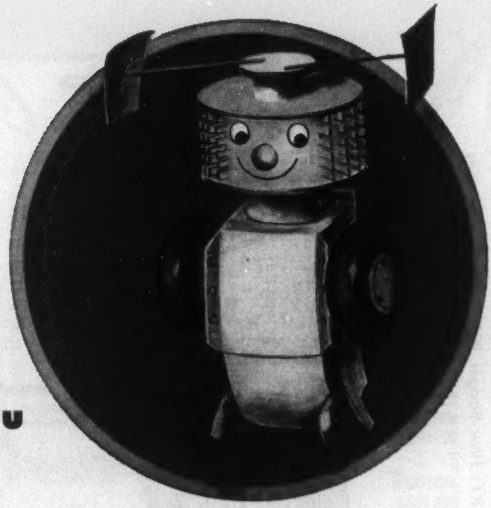

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increases water revenue 39.6%

from meters serviced in "roundup"

Increased revenue? *Really* lost revenue regained! A Midwestern community (name on request) stemmed an annual water revenue loss from old, inaccurate meters — turned it into water department *profits* with modern, accurate Badger meters.

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What makes the big difference in the meters Badger builds...

Exclusive Dovetail Thrust Roller Insert assures accurate registration

Case in point: Old style (A), with full length slot weakens chamber halves, makes them subject to distortion. New style (B) with 77% shorter slot retains original chamber strength and eliminates distortion. Dovetail design prevents shifting of insert but does not impair freedom of disc movement. Just one of many refinements in water meter construction available only with Badger's advanced meter design.

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The system was designed by Ford engineers in collaboration with consulting engineers R. F. Giffels and V. E. Vallet.

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MODERN WATER STORAGE at Pueblo, Colorado

750,000 gallon tank on 120 ft tower.
Diameter 62 ft. Head range 35 ft.

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ing the city of Pueblo typify the value, craftsmanship
dependability inherent in Pittsburgh-Des Moines water
age units of every type. Full information on the various
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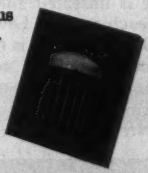

1,500,000 gallon capacity tank on 70 ft
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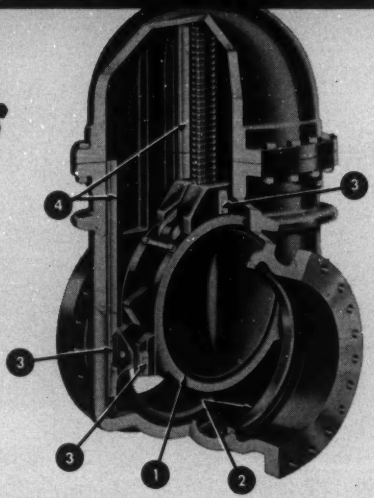
PDM
ELEVATED STEEL TANKS

SMITH THROTTLE CONSTRUCTION VALVES

ELIMINATES
disc tilting and chatter

REDUCES
wear of disc & seat ring faces



Smith Square Bottom Throttle Construction Valves have all of the time-proven design and construction refinements of standard Smith Gate and Tapping Valves and are recommended for severe service applications such as throttling in a partly open position, daily or frequent operation against high unbalanced pressure, high velocity or installation in a flat position in vertical piping.

The design features consisting of disc shoes and body tracks mechanically lift and hold the disc ring face (1) out of contact with the seat ring face (2) at all points of disc travel with the exception of the fully closed position.

Throttle construction valve discs are provided with three non-ferrous metal shoes (3), precision-machined and jig located. Valve bodies are provided with three non-ferrous metal machined tracks (4). The three disc shoes register with the three body tracks and each shoe is in contact with a track while the valve is unseated and in any partially open position. The bottom section of each track is bevelled to insure that the shoes will not bear on the tracks when the valve is fully closed.

This construction prevents damage to and uneven disc and seat face wear and assures long service life under severe operating conditions.

Single throttle construction is used when the flow is not subject to reversal. Double throttle construction when the flow is subject to reversal.

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QUICKLY LOCATES pavement covered manholes, valve covers, boxes, metal survey or property markers, lost and buried tools, metal beams, in fact any metal below surface or behind brick, plaster or stone siding. Weighs only 7 lbs. Baked wrinkle finish on metal with red lacquered wooden handle—moisture-proofed loop assembly. Send for and try this time tested and proven locator. Immediate shipment.

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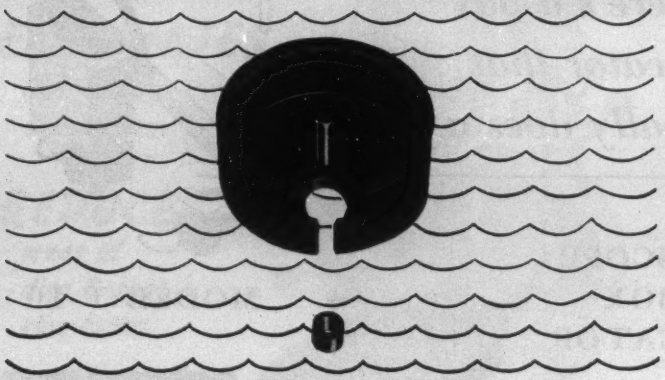
Less to wear—Less to repair!



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another fine product by

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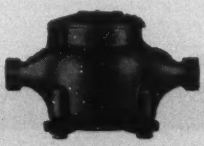
Top View



Side View

End View

"That's a smart question, son . . . and the answer is 'experience'."

Inside every Ludlow fire hydrant and every Rensselaer fire hydrant you'll find working and structural parts — developed through nearly 100 years of sound experience — that fill these four basic requirements for a perfect hydrant:

SIMPLICITY OF DESIGN AND OPERATION

ABSOLUTELY TIGHT CLOSURE

NO FREEZING

NO FLOODING DUE TO STANDPIPE BREAKAGE

All Ludlow and Rensselaer hydrants are built for easy, dependable operation and long life, despite rough treatment and the most severe climate conditions. They're engineered for *performance* and meet all A.W.W.A. specifications. That's why they've been "watchdogs" of American property since 1861!

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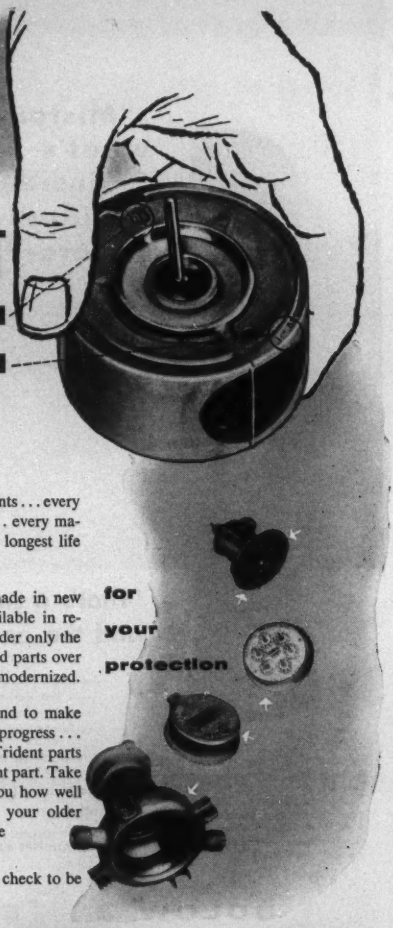

Trident water meters are precision instruments . . . every part made to extremely close tolerances . . . every material carefully selected and tested to give longest life in *your* water system.

Most important, every improvement made in new Trident meters immediately becomes available in repair parts for your older meters. You re-order only the latest parts. As you replace worn, out-dated parts over the years, your Tridents are *automatically* modernized.

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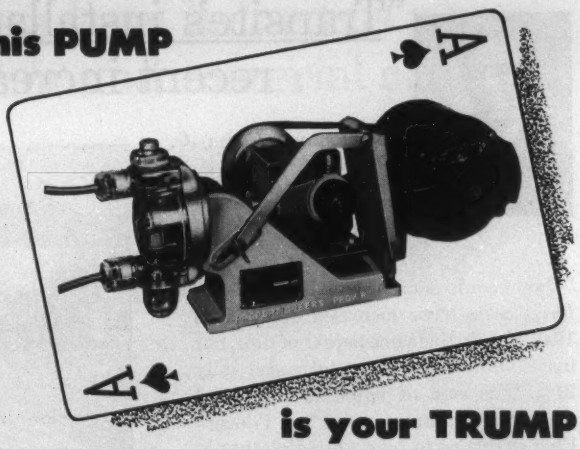
TRIDENT WATER METERS

This PUMP



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STERILIZE your own water supplies!

You'll win all around . . . with this "packaged" unit that contains everything needed to properly, safely, and dependably handle hypochlorite solutions . . . for sterilizing small water supplies, for emergency water sterilization, or for standby service.

You'll be playing it safe . . . because the basic unit is a Proportioneers Heavy Duty Midget Chlor-O-Feeder, the proportioning pump that has won such universal acceptance.

HERE'S THE WINNING HAND . . .

- Low initial cost, minimum upkeep expense due to simple, durable construction.
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"Transite's installation recent increases

Says Philip J. Holton, Jr.
Chief Engineer
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Providence, R.I.

"Our records show that labor and material costs have increased 100% since 1946. Yet, in this same period of time, our installation costs have increased only 21%. The ease of handling and speed with which contractors can lay Transite Pipe enable us to take full advantage of modern equipment and methods. In this way, Transite has played a prominent part in helping us offset increased costs."

Transite Pressure Pipe helps you cut system costs 3 ways: in design—installation—operation!

Today, in every part of the nation, municipal and consulting engineers choose Transite® Pressure Pipe. Ask why, and you find that economy is always among the Transite advantages they consider most important. For no pipe does so much to help keep your costs low in these three different ways:

1. Design. Transite lets you plan a system for maximum efficiency. For its high carrying capacity (flow coefficient, C=140) often lets you specify pipe of smaller diameter. And because Transite's smooth interior remains smooth, you never need to make costly allowances for future reduction in carrying capacity.

2. Installation. Transite's installation speed cuts time and labor costs substantially. Light in weight for so durable a pipe, it handles easily above and below ground. And its Ring-Tite Coupling assembles quickly, surely . . . giving you a tight

savings have helped us absorb in labor and material costs..."

Crews of Fanning and Doorley Construction Co. installing 8" line in Providence, R. I.

seal at every coupling in the system.

3. Operation. Here's where Transite really saves! For its maintained carrying capacity keeps pumping costs low year after year. Its strength, durability and corrosion resistance cut maintenance to a minimum, provide years of trouble-free service.

Transite's Ring-Tite® Coupling cut away to show how rubber rings are compressed and locked in place to form a tight yet flexible joint.

We'll be pleased to send you booklet TR-160A.
Write Johns-Manville, JN Box 14, N. Y. 16, N. Y.

"Good Water, the Lifeblood of your Community"
Let's promote it—Let's have it!

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100 YEARS OF QUALITY PRODUCTS . . . 1858—1958

JOHNS-MANVILLE JM PRODUCTS

Table of Contents

PAGE

Do You Buy "Price" or "Value"?
By Dr. Morris M. Cohn 81

New England's Contribution to the Water-Works Profession
By E. Sherman Chase 88

Seventy-five Years of Water-Works Progress in Maine
By Dr. E. W. Campbell 98

History of Water Supplies in New Hampshire, 1882-1957
By William A. Healy 122

Seventy-five Years of Water-Works Progress in Connecticut
By Warren J. Scott 127

Seventy-five Years of Water-Works Progress in Rhode Island
By Walter J. Shea 134

Seventy-five Years of Water-Works Progress in Massachusetts
By Clarence I. Sterling 138

Seventy-five Years of Water-Works Progress in Vermont
By Edward L. Tracy 143

The Geohydrology of New England
By Rev. Daniel Linehan, S.J. 149

Actual Trends in Sanitary Engineering and Water Supply in Europe
By Prof. W. F. J. M. Krul 160

Developments in Equipment for Water Works in New England
By R. S. Rankin 190

Memoir of Frank Lee Flood 215

Proceedings:
February 1958 Meeting 217
March 1958 Meeting 219

NEW ENGLAND WATER WORKS ASSOCIATION
ORGANIZED 1882

VOL. LXXII JUNE, 1958 NO. 2

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DO YOU BUY "PRICE" OR "VALUE"?

BY DR. MORRIS M. COHN*

[*Read September 16, 1957.*]

In a frank discussion of the gentle art of *buying*, it is well to invoke the age-old precept: "Let the buyer beware!" In this spirit I must warn you that your program committee bought, for my share of this technical session, not a *technical paper*, but something that may sound strangely like a *sermon*. It is for you, therefore, to beware of what I have to say. If my ideas do not fit your needs, do not "buy" them.

For this off-beat program assignment I offer two abject apologies. First, I am in the position of the minister who felt like discontinuing his sermons because those who came did not need them and those who needed them did not come. I infer that the dyed-in-the-wool water-works men who attend this meeting need no sermon on "value" vs. "price".

Secondly, I make apology because anyone who has the brashness to tell New England Yankees why "value" is more important than "price" is talking to folks who know how to get both at one and the same time!

Despite these valid reasons for not expounding on my favorite theme, your invitation merited acceptance and I am on hand to face what an editor always faces—repeating and reasserting his already-on-the-record position. There need be no apology at this time for focusing the attention of the water-works profession on the need for quality materials to guarantee quality water and quality service. We stand at the threshold of great national growth during which water is to play a vital role, so great a role, in fact, that without adequate water we shall not achieve the progress of the future.

It is the solemn responsibility of the water-works industry

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to provide this ingredient of national progress, and it will take the best in materials, mechanisms and methods, as well as the best in qualified professional personnel, to supply enough water to make our future fluid.

We are growing in water needs for "people, plastics and potatoes"—as I recently told the New York Section—far beyond the imagination of early planners. Our national population is growing at the rate of 8 bpm—babies per minute (a new unit of measurement in the water-works field)—and predictions of a national population of 220,000,000 by 1975 are capable of substantiation: industry will expand its "plastics" to nearly double our present capital-goods level and our future national capital output will make light of the $500 billion mark to which we now aspire. Agriculture will tap water resources for its "potatoes" at an equally alarming rate.

To provide water for *people* and *production* is the solemn responsibility of public water-supply systems. To meet this responsibility will mean construction of new water facilities and expansion and modernization of existing systems at a rate that will totally overshadow the past, even the past two decades when we invested more in water-works facilities than in all of the years since the introduction of public water supplies.

Using the deflated value of the dollar of the early 1950's, it is estimated that the water-works industry is now utilizing facilities having a replacement value of some $25 billion, placed in, on and above the ground in about a century and a half, with the past 100 years witnessing a growth in the number of water-works systems from approximately 125 in 1857 to some 15,000 in 1957. It is challenging that the investment value of water-works facilities needed to serve today's and 1975's needs totals another $22 billion, based on the ability of our spiralling economy to peg the value of the dollar. As the dollar shrinks these costs will expand, by unfortunate inversion. It is, indeed, a challenge that Federal agency statistics warn us that only 58% of our water-works systems are now considered adequate, and that a large share of our investment needs must be plowed into bolstering such deficiencies.

The conviction grows that only the best is good enough in construction and operation materials, to meet the demands for all this water, all of the time. We must guard ourselves against

buying for *price*, instead of *value*, under such challenging circumstances.

I need not belabor the fact that so much of our water-works investment dollar goes into the cost of money, borrowed for financing projects, and for other non-operable items such as construction labor, cost of land, movement of earth, concrete, brick and steel—that the price of the *best* in mechanisms, materials and methods for the movement of water from source . . . to pumping station . . . to treatment plant . . . to distribution system . . . to storage . . . and to measurement and "cash-registering" facilities, is but a fraction above the cost of *minimum* quality and price. It is easy to demonstrate that for every dollar spent on water-supply construction, 27 cents are expended for labor—16 cents for uncontrollable overhead costs—2 cents for non-operable supplies—and another 3 cents for miscellaneous materials totally unrelated to the ultimate ability of the system to take water in and put it out at the far end of the line. With 48 cents used in this manner, need we argue about the importance of the quality of the balance of the dollar?

The water-works field is an interesting composite of operations. It includes public and private agencies, both dedicated to efficient public service. Yet, publicly-owned water systems may be hampered in rendering that public service by the mere fact that laws have been enacted to provide "checks and balances" in expenditures, as a means of protecting the public against the abuse of public funds. Private water facilities, on the other hand —and I speak broadly of necessity—are not hampered by such legal regulations, covering what is bought, how it is bought, from whom it is bought and how much is paid for it.

It is well to explore why some manufacturers express preference for selling to private companies, rather than to public agencies. It is well, also, to explore why it has been said that the government "buys by chance", while private utilities "buy by choice"! It is safe to say that private water companies buy with intelligence and economy; the question is: Cannot public agencies profit from their practices?

The answer to this difference in water-works purchasing practices, if, indeed, there is one, lies in the governmental provision that major purchases must be made by competitive bidding

and that the purchase must be made from the "lowest bidder" who is "responsible" and offers goods which are "in conformity" with that specified. There have been moves afoot to ease the rigidity of this governmental purchasing provision, on the grounds that the suspicion of governmental operation which apparently induced the placing of such restrictive purchasing laws on the statute books no longer exists.

Without doubt, municipal purchasing restrictions requiring competitive bidding and low-bid acceptances were designed to protect public funds from diversion, dissipation and duplicity through favoritism, chicanery, whim, caprice and other frailties of the human animal. If government is now better than it was in the past . . . if the public is more enlightened and better informed . . . if the ballot box is now a more potent tool against the official who should not have been in a position of trust, in the first place . . . if the era of haunch-paunch-and-jowl municipal officials has come to an unlamented end . . . then there is every reason for ameliorating the rigidity of municipal purchasing laws. We may well seek such flexibility in our own field, to match the buy-by-choice freedom of the private water utility. If we never try, I fear we shall never achieve such a goal, even though a lifetime of municipal service leaves me in some doubt as to whether we can ever fully achieve this aim.

It is significant that several state municipal associations have been fighting for open-market purchasing privileges beyond so-called standard $500 limits, on the grounds that the value of money has depreciated and that purchasing limitations should recognize this unavoidable fact.

There need be no argument for *quality* buying instead of *price* buying in the water-works field. We should know from long experience that there are two sides to the price ticket and that both sides are of equal importance. Yet, there stand the present laws, inviolate. The question is: Are these laws actually restrictive, or have we caused ourselves to be restricted by our own shallow thinking? Are we being "hoist with our own petard"?

It is my fear, based on some three decades of close contact with municipal affairs, ranging from conception and specifying of engineering materials, through the construction and opera-

tion stages, that, much as I might plead for full freedom of decision without restrictive purchasing laws, I am aware of the fact that we may have failed to get what we want in the "Three M's" of materials, mechanisms and methods, due, in many cases, to our own indecisiveness.

"Competitive bidding" is another way of saying "specifications". "Specifications" is another way of saying "knowledge of what is wanted". If this simple word transition holds true, there *is* a legal way to buy "value", rather than "price", without being restricted by or concerned over the "low bid" provision of the law!

The answer lies in more positive specifications, spelling out exactly what the municipality wants in equipment, materials and supplies. There is reason for believing that some municipal misfortunes in buying stem from poorly written specifications or even indecisiveness over what is really wanted. If there is indecision, under the guise of "open" specifications, it becomes unfair to blame a bidder who presents an offer based on the lowest quality that will meet the specification requirements. This, unfortunately, imposes a hardship on the manufacturer whose products exceed the minimum requirements.

John Ruskin, many years ago, had something to say about this price and quality situation; his philosophic pronouncement is equally applicable today. He said, "There is hardly anything in the world that some men cannot make a little worse and sell a little cheaper, and the people who consider price only are this man's lawful prey." The price ticket is not the true measure of the economy of a purchase. In fact, to quote an old cliché, the quality is remembered long after the price is forgotten.

In water-works practice, this is all too true. A failure is a calamity. We cannot bury our mistakes; much of our facilities are "buried" for long-time *forgetting*—but for equal long-time *service*. It takes too long to win funds for water-works improvements to squander them on short-life or short-service facilities. The responsibility to the public to protect its funds is too great to be disregarded. To limit our responsibility to adherence to the competitive-bidding law is to discharge the responsibility in only a minor degree. It is our responsibility to guarantee that public monies are best invested in quality facilities.

When we argue for reduction or elimination of restrictions in governmental purchasing, there should be an equal and compensatory increase in the responsibility of the water-works official to take up the gap created by any such easing of legal "thou shalts". The responsibility is, therefore, the purchaser's to know what he wants, what he will be willing or able to pay for it, and how to specify what he wants so that bidders will know, without question, what they must supply. If this is done, the "lowest conforming bidder" is the legitimate party of the second part, and if the purchaser does not get what he wants, the fault is his and his only.

Such a responsibility can be discharged only with *knowledge*. *Honesty* is not enough, if we are to have the power to write specific specifications and to make them stick. We must know: (1) What is available from recognized manufacturers; (2) How it can be applied to the specific needs; (3) How available facilities can be modified to meet these needs. This three-dimensional criterion will, in many cases, entail conferences with manufacturers, the availability and use of exploratory specifications, and the avoidance of gadgets, gimmicks and "gismos".

The best way to assure these important factors is by maintaining an open door, through which can flow the information that manufacturers have available and which specifiers may not be expected to possess in their own professional fund of knowledge. This is the age of specialization, and the makers of equipment, which has made possible our great mechanization progress, have the specialized knowledge which the specifier frequently needs. These manufacturers have earned the right to help guide purchasing policy, particularly in the mechanization and instrumentation fields, because they have made it possible to convert our water-works operations "from grunts to gears" and "from sweat to switches".

If we maintain an open door between industry and government, we can become the recipients of data which can do much to write "or equal" quality into projects without sacrificing the original quality standard. The recognized equipment and materials manufacturer retains in his employ the "cream of the crop" in engineering talent; the calibre of these men, backed up by the full faith and dependability of the manufacturer, is our

best guarantee of the ability of this type of team play to have beneficial effects on the true quality of future water-works projects.

A close bond between the maker and the specifier should stimulate the development of higher quality in products and the creation of new commodities to meet new needs. If anything, this open-door policy should result in greater opportunity for competition in bidding, based on intelligent "or equal" products, rather than restricting the open competition upon which a free enterprise thrives. Using this spirit, water-works specifications have the opportunity to become a new universal language, a new water-works engineering Esperanto, which will eliminate cloudiness and replace it with clarity, convert fantasy into facts, and help rather than hinder progress in the production and purchase of the materiel of water-works construction and operation.

It takes a drought to demonstrate the true value of water. Similarly, it takes the great and expansive predictions of long-range planners to focus attention on the importance of adequate water systems to water and nourish the urbanization and industrialization which we prophesy for the next two decades. We are at the threshold of magnificent developments in the water-works field, and we must think magnificently if we are to achieve the goal of enough water to meet the needs of a wet-living and wet-processing nation. Whether it be in planning, procuring, treating, pumping, distribution or accounting for the vital commodity with which we deal, the product cannot be cheaply produced or cheaply sold. We must build quality, not price, into our service.

Fortunately, our profession is served by an industry which, by reverse Ruskinism, demonstrates every day that "There is hardly anything that some man cannot make a little better". This striving for better water-works value, without the hampering influence of the price ticket, proves the validity of Thomas Jefferson's admonition—"Never buy what you do not want because it is cheap; it will be dear to you."

I referred a few moments ago to the "magnificence" of the water-works future. How better finalize this sermon—which I need not have delivered in the first place—than with the admonition of Samuel Johnson: "Magnificence cannot be cheap, for what is cheap cannot be magnificent."

NEW ENGLAND'S CONTRIBUTION TO THE WATER-WORKS PROFESSION

BY E. SHERMAN CHASE*

[*Read September 17, 1957.*]

New England is small, very small, but its contributions to the nation have been mighty. Looking backward we see the Mayflower Compact with the covenant of "just and equal laws"; we see the Declaration of Independence written by Jefferson of Virginia with the wise counsel of Adams, of Quincy, and Franklin, New Englander by birth; we see the beginnings of the industrial revolution with Samuel Slater's spinning mill in Rhode Island and the textile mills of Lawrence and Lowell, Massachusetts; we see the flowering of New England's art and literature; we see the establishment of scientific schools at Yale and Harvard, and the founding of the Massachusetts Institute of Technology in Boston; we see the telephone created by an obscure professor of Boston University; we see another professor from Harvard disclosing the vast mineral resources of the country; and we see the financing of the transcontinental railroads with New England capital and, as the king says in "The King and I," et cetera, et cetera, et cetera. Yes, New England is small, but its impact upon the nation has been and is far out of proportion to its size in area or population.

As in the few instances I have just cited, so have New England's contributions to the water-works profession set the pattern for water-works practice in the United States. The first public water supply in the country was a crude spring-fed reservoir, constructed in Boston in 1652. Up to 1800 there were only 16 municipalities with public supplies. Of these eight were in New England:

Boston	(1652)
Providence	(1772)
Salem	(1792)
Plymouth	(1796)

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Hartford (1797)
Portsmouth (1798)
Worcester (1798)
Peabody (1799)

The first treatise in the United States dealing with water-works engineering, with special emphasis upon hydraulics, was published in 1835 by Charles S. Storrow. Storrow, a graduate of Harvard College, served as a pupil of Loammi Baldwin, the father of engineering in this country. He studied in France and wrote this treatise while abroad.

The second important book, still valuable today, was published in 1876 by J. T. Fanning, an eminent New England engineer who later moved to Minneapolis. In the preface to his "Practical Treatise on Hydraulics and Water-Supply Engineering," written in Boston, November, 1876, Fanning makes the following comments:

"A numerous band of engineering students are graduated each year and enter the field (engineering), many of them choose the specialty of hydraulics, and soon discover that their chosen science is great among the most noble of the sciences, and that its mastery, in theory and practice, is work of many years of studious acquirement and labor. They discover also that the accessible literature of their profession, in the English language, is intended for the classroom rather than the field, and that its formulae are based chiefly upon very limited philosophical experiments of a century and more ago, but partially applicable to the extended range of modern practice."

Fanning goes on to say that the object of his pioneer treatise was to inform water commissioners on the best practice; to instruct junior engineers; to provide practicing engineers with tables of data to ease their labors; and to present to civil engineers a concise reference manual, relating to the hydrology, hydrodynamics, and practical construction of the water-supply branch of their profession. These objectives of Fanning could well be claimed by the New England Water Works Association as their own.

I have referred to Loammi Baldwin whose house still stands in Woburn. In 1834, Baldwin reported and recommended the development of the Cochituate supply for Boston. In 1837, his

brother James again recommended the Cochituate development, but only after protracted controversy was the recommendation adopted in 1846. To James Baldwin, together with E. S. Chesbrough and W. S. Whitwell, was given the responsibility of bringing the project to a successful demonstration with the introduction of Cochituate water on Boston Common on October 25, 1848, and final completion in 1850. Incidentally, James Baldwin was the first president of the Boston Society of Civil Engineers.

E. S. Chesbrough, associated with Baldwin on the Cochituate scheme, was the first city engineer of Boston. Later he became chief engineer of the Board of Public Works of Chicago, in charge of water supply and sewerage. He was a consultant on water works and sewerage in the United States and Canada. He was consultant to New York upon the Croton water supply of that city.

While in Chicago the first lake-water tunnel was completed in 1867 under Chesbrough's direction. This feat of engineering brought him international recognition. It is interesting to note that Chesbrough, lacking almost any formal education, was the recognized head of the sanitary engineering profession in this country for many years.

New England's contribution to water-works engineering began with particular attention to hydraulics, as demonstrated by Storrow's treatise of 1835 and the later one of Fanning in 1876. Other early noteworthy contributions in this field were made by New England engineers. Uriah Boyden (1804-1879), who opened an office in Boston in 1840, invented the hook gage and other devices related to water wheels and turbines. In 1855 James B. Francis (1815-1892) published his "Lowell Hydraulic Experiments," one of the most valuable contributions to the science of hydraulics. Francis was one of the incorporators of the Massachusetts Institute of Technology.

Later contributions in the field of hydraulics were made by Clemens Herschel by the invention of the venturi meter (Trans. ASCE-1887); by John R. Freeman in his work on water-supply requirements for fire protection and the hydraulics related thereto; and by Gardner S. Williams and Allen Hazen by their publication of their invaluable "Hydraulic Tables" and the invention of the hydraulic slide rule. Herschell, Freeman and Hazen were past presidents of the New England Water Works Association.

In recent times significant studies of hydraulic problems related to water-works systems have been made by living members of this Association. The 1935 committee report on friction coefficients is but one of the many which are particularly noteworthy.

In the field of hydrology New England engineers have been pioneers. Of those outstanding in this branch of the water-works profession were Freeman, Frederick P. Stearns, Caleb M. Saville and Desmond Fitzgerald, all past-presidents of this Association. The NEWWA committees on yields of catchment areas are outstanding examples of contributions made to water-works practice.

It is difficult to know in just which phase of water-works engineering New England has contributed most. In my opinion there are two fields in which it is a tossup as to which New England has been most influential; namely, technical education and water purification.

In the field of education we can start with Loammi Baldwin, who took young men into his office and taught them the principles of engineering of his day. Among these were Storrow, of whom I have spoken. There were others who became prominent in after years. These were the days prior to the establishment of formal engineering schools. Many of the early water-works engineers, E. S. Chesbrough for example, were largely self-educated.

Formal engineering and scientific education appears to have became a factor in water-works practice only about three quarters of a century ago, coinciding more or less with the formation of the New England and the American water-works associations. The application of science to water-works practice, aside from hydraulics, was related in a considerable degree to the quality of water. In this field there were a few outstanding chemists. Prof. E. B. Horsford (1818-1893), dean of the Lawrence Scientific School at Harvard, established there a department of chemistry. He was also one of the incorporators of the Massachusetts Institute of Technology. In his day he was one of the authorities on water quality and made one of the earliest studies on the use of lead pipe for services. As far back as 1854 Prof. Horsford made studies of the quality of the Cochituate supply.

Two professors of chemistry at M.I.T. can be listed as the

water-quality experts of their day; namely, William Ripley Nichols and Thomas M. Drown. The latter became president of Lehigh University. These chemists contributed classical papers upon the character of water, mainly from the chemical viewpoint. Both had much to do with the early activities of the State Board of Health in Massachusetts.

Apropos of water quality, this may be a suitable time to quote from Geddes Smith's "Plague on Us," describing the character of water supplies a century ago:

> "The appearance and quality of the public water supply were such that the poor used it for soup, the middle class dyed their clothes in it, and the very rich used it as top dressing for their lawns. Those who drank it, filtered it through a ladder, disinfected it with chloride of lime, then lifted out the dangerous germs which survived and killed them with a club in the back yard."

This description may well be exaggerated, but it does contain certain elements of truth. It also illustrates some of the causes which brought into being that outstanding event in sanitary engineering, the establishment of the Lawrence Experiment Station by the Massachusetts State Board of Health. M. N. Baker, in his "Quest for Pure Water" writes as follows:

> "During the middle and latter years of this quarter century (1875-1900) there appeared a group of pioneering chemists, biologists and engineers, whose fundamental investigations at the Lawrence Experiment Station in Massachusetts prepared the way for the application of scientific principles to water purification and sewage treatment. These were the days in which a group of brilliant young men under the leadership of Hiram F. Mills began careers which meant so much to the practice of sanitary engineering in the United States. Their accomplishments, like the shot at the Concord Bridge 'were heard 'round the world'. The group consisted of the chemists Allen Hazen and Fuller, and the biologist and teacher, William T. Sedgwick of M.I.T. Coworkers and pupils of these men, and pupils of their pupils, probably constitute the bulk of sanitary engineers in the United States today and their influence has been felt far beyond the confines of North America."

Of the men associated with the pioneering work of the Lawrence Experiment Station practically all achieved the highest rank in the engineering profession.

The biologist and educator, William T. Sedgwick, was with-

out exception the most inspiring teacher it was my good fortune to encounter. He was at one time the president of this Association and presented numerous papers to it. Robert C. P. Coggeshall, superintendent of the New Bedford Water Works and past-president of the NEWWA, in a paper delivered in September, 1902, has this to say about Sedgwick:

> "No one has complained that he could not understand every word of Prof. W. T. Sedgwick's admirable addresses to this Association; and he always secures the delighted attention of the practical worker. The scientist that follows this plan is the true educator, and makes an ideal member of such a society as this. He interests the practical worker, and is sure to unconsciously influence his future thoughts. The worker in turn gladly aids him to new observations and the receiving of data for new investigation. By such a process as this, the ideas of the worker will constantly aspire to higher standards."

Probably no other man before or since has had so much influence on sanitation in this country. Pupils and fellow workers of Sedgwick and, in turn, their pupils and associates have been responsible for most of the improvement in the quality and safety of the water supplies of the United States.

George W. Fuller, for instance, by his classic experiment at Louisville demonstrated the effectiveness of rapid sand filters for the purification of the muddy waters of the Middle West. Hazen in 1895 wrote his classic "The Filtration of Public Water Supplies." Robert Spurr Weston carried out investigations on the treatment of the New Orleans supply from the Mississippi; Edwin O. Jordan became professor of bacteriology at the University of Chicago; Harry W. Clark and Stephen De M. Gage carried on further researches at the Lawrence Experiment Station. The list of those whose life work, devoted to water-quality control, developed from the inspiration of those early pioneers is too long to recount. Their name is legion.

In the field of algae study and control, New England has pioneered. As far back as 1845 John B. Jervis, Chief Engineer of the Croton Water Works, and Prof. W. R. Johnson of Philadelphia were engaged by the city of Boston to investigate various proposed sources of supply, including Lake Cochituate, Spot Pond and Charles River. Temperatures were taken at different depths and samples collected for microscopic and chemical analy-

ses. Although reporting that the "animalcules" found in the samples were not harmful, in and of themselves, the investigators pointed out the conditions under which they might be objectionable. They anticipated, according to M. N. Baker, some of the conclusions reached by Desmond Fitzgerald, Fayette Forbes and George W. Rafter many years later.

Some 52 years ago, almost to a day, this Association held a noteworthy symposium of papers upon "The Use of Copper Sulphate and Metallic Copper for the Removal of Organisms and Bacteria from Drinking Water." The list of contributors of these papers is indeed impressive. First was Dr. George T. Moore of the Department of Agriculture, whose classic contributions with Karl F. Kellerman on the use of copper sulphate as an algicide are well known. Other contributors were Prof. W. P. Mason of Rensselaer Polytechnic Institute; Daniel D. Jackson, Director of the Mt. Prospect Laboratory in Brooklyn; Prof. Henry Kraemer of Philadelphia; Prof. Herbert E. Smith of Yale Medical School; Joseph W. Ellms of Cincinnati, Ohio; Harry W. Clark of the Lawrence Experiment Station; George A. Johnson of the Columbus, Ohio, Sewage Testing Station; X. H. Goodnough, Chief Engineer of the Massachusetts State Board of Health; Karl F. Kellerman; Earle B. Phelps, then at M.I.T.; Dr. George N. Soper, Consulting Engineer, New York; Allen Hazen; P. A. Maignen, filtration engineer, Philadelphia; and George C. Whipple (of whom more later).

Reference has been made in previous papers today to the establishment of the first laboratory for the routine testing of water at Brookline. This laboratory was established by Desmond Fitzgerald, and in it was employed a recent graduate of M.I.T., George C. Whipple, who later established the Mt. Prospect Laboratory in New York, and whose book, "The Microscopy of Drinking Water," has been the guide of the water-works man for years.

Along the lines of water-quality control, it may not be amiss to point out that the first edition of "Standard Methods for Water Analysis" was prepared by a committee made up largely of New England-born or New England-educated men.

In the development of some of the larger water-works systems in the United States, New England engineers have played

notable parts. This is particularly true of New York City, where successive chief engineers of the Board of Water Supply, starting with J. Waldo Smith, have been New Englanders. It is interesting to note that one early engineer, Joseph P. Davis, who was connected with the Boston works and later was consulted with respect to the New York supply, became eventually chief engineer of the American Telephone and Telegraph Co. This illustrates the versatility of water-works engineers. Parenthetically, it may be mentioned that James F. Baldwin was engineer for the Bunker Hill monument and that Clemens Herschel was the engineer for the bridge across the pond in the Public Garden.

In the field of equipment and materials it is necessary to add but little to Mr. Rankin's admirable paper. New England inventiveness has been demonstrated in the fields of pumping equipment, valves, meters, instruments and controls. The brass and copper industry of the region has performed an important part in the fabrication of water-works equipment.

Another interesting part played by water-works engineers of New England and by members of this Association relates to their participation in the affairs of national engineering societies. At least eleven former or present members of the NEWWA have been presidents of the American Society of Civil Engineers. Several have been presidents of both associations, and several have been presidents of the American Water Works Association.

This talk has been an attempt to compass in half an hour the contributions of New England to the water-works profession over a period of a century and a half. It has been possible to hit but a few of the high spots, to mention a limited number of outstanding personalities and to present only a few of the relationships of New England engineers to water undertakings in the rest of the country. Omissions are many. For those interested to pursue this historical study further, I commend the papers in the centennial issue of the Journal of the Boston Society of Civil Engineers, October, 1948. M. N. Baker's "Quest for Pure Water" is without doubt the most exhaustive historical treatise on water purification. I also suggest the rereading of the 70 volumes of the JOURNALS of this Association.

A fully comprehensive paper would have discussed many more topics than have been covered in this brief paper, and many

more outstanding men in the water-works field would have been extolled. Among the subjects to which New England engineers and scientists have contributed much are those relating to specifications, water rates, valuation procedures, water-works construction, lead poisoning, chlorination and seismic exploration, to mention but a few.

In closing, I cannot resist giving the Association a pat on the back by quoting from our distinguished Honorary Member and Past-President, Caleb Mills Saville:

> "I believe it to be a fact that, although a semi-technical association, its contributions to water supply science have not been excelled by any other body in the world."

Let us here resolve that (as in our glorious past) these words of praise shall be deserved today and in the future.

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Microscopy of Drinking Water—George C. Whipple.
The Value of Pure Water—George C. Whipple.
Typhoid Fever—Whipple, Fair and Whipple.

SEVENTY-FIVE YEARS OF WATER-WORKS PROGRESS IN MAINE

BY DR. E. W. CAMPBELL*

[*Read September 18, 1957.*]

As a fitting development with this Diamond Jubilee Convention of the New England Water Works Association, the State of Maine may well be congratulated in that the last session of its legislature decided to follow the lead of many other states and establish supervision of public water supplies under the state health authorities. This is known as Chapter 269, Public Laws of Maine, 1957, a copy of which is included as an appendix to this discussion. The principal accomplishment of this new law is to make the Department of Health and Welfare directly responsible for supervising the safety of public water supplies and to make reasonable rules and regulations for the adequate operation of all water purification equipment. To make this result possible it requires the submission of plans of all new water purification equipment to the department for their advice before any replacement of a major portion of an existing system of water supply or purification plant before installing or replacing such facilities, but does not require the submission of plans for minor repairs, alterations, relocations or extensions of existing systems. This control—previously vested in the Public Utilities Commission—will now make possible closer and more satisfying contacts of the Maine State Department of Health and Welfare and its Sanitary Engineering Division with the water-utility officials of the state.

Previously the Sanitary Engineering Division has had close contacts with water-works officials, mostly on an emergency basis, and has been enabled to assist and advise on the treatment and sterilization of public water supplies. For many years it has also maintained the laboratory where samples from the various water utilities have been regularly tested. Results of such analy-

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ses have been reported to both the utility involved and the Public Utilities Commission from whom directives have been issued when needed for necessary corrections. This method of operation was a result of legislation adopted in 1917, at which time there was considerable readjustment of the Maine governmental functions. At that time there was a measure introduced into the Maine legislature intended to strengthen the State Department of Health and place under it supervisory control of public water systems. This proposal very closely followed the then existing Massachusetts water-control acts, but it was reported to the legislative committee, hearing the bill at that time, that the Health Department actually had no engineering staff in existence and the Public Utilities Commission did have such an engineering staff, and that control of the sanitary quality and safety of public water utilities should be vested in that commission as part of their existing engineering section, to strengthen and develop their financial control, which had been continued from the previously existing Railroad Commission. This measure, when passed, did much to regulate public water supplies and provided machinery for elimination of conditions which were polluting or tending to pollute sources of public water supply. It also made possible the requirement of complying with sanitary standards.

The history of the development of water supplies in the State of Maine is lost with the passing of many elderly citizens who carried with them what information there was available concerning the beginnings of many of our early water systems, and a complete lack or inaccuracy of early records is such that, at best, in a short talk it will not be possible adequately to outline the development of water supplies in our state. If we are only going to consider those which have developed in the past 75 years, we can very briefly dispense with the very earliest public water-supply systems. These in many cases started from a private water supply from a spring, or similar source, piped to some well-to-do citizen's home. He then, allowing some of his employees or neighbors to connect onto this system, created a small public water supply.

The earliest supplies of record are those developed in Skowhegan, Maine, starting in 1830 with the Central Aqueduct system which was discontinued in 1943, and with the Skowhegan

Aqueduct, West Skowhegan Aqueduct, and a third called the Skowhegan Water Company. All of these apparently started in 1836 and subsequently were absorbed into the present Skowhegan Water District.

The town of Paris was the scene of a number of these aqueduct systems, such as the Hillside, Crystal Fountain, and Paris Hill Aqueducts, started between 1860 and 1865. Of these the Paris Hill Aqueduct provided the water for a very interesting community around the old Court House on Paris Hill, where Hannibal Hamlin started to practice law before he became Vice-President of the United States.

Although the city of Portland may have had some small independent water supplies for limited areas, there seems to be no record of any municipal system prior to 1868. Apparently this was when the principal water supply of that city was developed. This was only a year before one was started in the city of Auburn, and six years later systems were started in the city of Bangor and the town of Bar Harbor. Lewiston was about ten years later in establishing its municipal system. At the same time water supplies were developed in the towns of Springvale and Milbridge.

These may well be said to be the beginning of the present 75-year era in water-supply development. Most of the municipal water systems in Maine have been established since that time. Peculiarly enough, water-supply systems were developed in some of the more remote areas early, such as Fryeburg in 1882, as well as a spring-water system in the town of Castine (probably merely an expansion into a municipal system of a private spring-water supply), which, from all the information available, appears to date back to the days of the early settlement of Castine in the 1600's.

In the early 1880's it may be said that the truly progressive era in the construction of municipal water works started in the State of Maine. To mention a few—Biddeford and Saco in 1884, Gardiner, Rockland and Houlton in 1885, Norway, Augusta, Brunswick, Calais and Richmond in 1886. The years 1887 to 1900 showed tremendous activity, hardly equaled during any other comparable period. Activity in the construction field continued, however, with a half-dozen more municipal systems con-

structed each year through the 90's and up to about 1906. At this time another period of activity developed, with seven municipal systems constructed in 1906 and approximately ten in each of the years 1908 to 1911, inclusive. Each year since, however, has shown the development of some new water systems.

In 1902 and '03 there was a development which very forcibly brought to the attention of health authorities and builders of public water works that it was necessary not only to construct municipal water systems, but also to make some provision for protecting the quality of such waters. The use of river waters receiving wastes from communities upstream had long been known to be a potential hazard, but this was forcibly demonstrated by the outbreak of a very severe epidemic of typhoid fever in the Kennebec River valley, which raged through the years 1902 and '03. This was very carefully investigated by the late Professor George C. Whipple from whom many of you as well as I received instruction. His report was printed in "Water-Supply and Irrigation Paper No. 198", published by the United States Geological Survey and entitled "Water Resources of the Kennebec River Basin, Maine", with a "Section on the Quality of Kennebec River Water" by George C. Whipple, printed in 1907. I think it is of sufficient general interest to quote from this report the following paragraphs:

> "The typhoid-fever epidemic of 1902-3 began about the middle of November, 1902. It was first noticed at Waterville, where for about a month new cases were reported at the rate of one a day. On Christmas day there were five new cases and during the next week the daily number of cases was the same. Thirteen were reported on New Year's day. After the middle of January the number of new cases fell off, but they continued to be reported at intervals until March. In Fairfield, Winslow, and Benton typhoid fever occurred at the same time. The largest number of cases was reported during the first two weeks of January. These four communities had the same water supply, namely, that of the Messalonskee River, and from the first it was evident that this was the cause of the epidemic.
>
> "As the sewage of these typhoid-fever stricken communities emptied into the Kennebec River and as the water of this river furnished the supply of Augusta, it was almost inevitable that the epidemic should extend to that city also, and this is what actually occurred. During the latter part of November and the whole of December new cases of typhoid fever occurred daily in Augusta. It seems probable that these earlier cases were due to the same source of infection that

caused the epidemic at Waterville, inasmuch as the Messalonskee River, which supplied that city, discharges into the Kennebec above Augusta. It was not until about two weeks after the climax of the Waterville epidemic that the serious period of the Augusta epidemic began. During the latter part of December and throughout the months of January and February the sewage at Waterville must have been infected with typhoid-fever bacilli; and, making due allowances for the periods of sickness, transmission, and incubation, this time corresponded with the duration of the epidemic at Augusta. After the Waterville epidemic had ceased and sufficient time had elapsed for the patients to recover the epidemic at Augusta came to an end."

It would be incomplete not to indicate the number of cases of typhoid which developed during the period of January, 1902, to May, 1903, from the Waterville public supply in the towns of Waterville, Fairfield, Winslow, and Benton, which was 371; and from the Augusta public supply during the period January 1, 1902, to January 1, 1904, 311 cases. Those of you who may be interested in this historical event will probably find the report, which I describe, very interesting. As a result of this epidemic both Waterville and Augusta abandoned the rivers as sources of water supply and developed water systems from nearby lakes—Waterville from China Lake, a distance of approximately eight miles, and Augusta from Carleton Pond, approximately the same distance from the city. In both cases the water arrives at the city by gravity, but requires pumping to elevated reservoirs for necessary working pressure.

It is an ill wind that doesn't do some good, and this epidemic was no exception, as it promoted the establishment of a laboratory for the State Board of Health in 1903, called the Laboratory of Hygiene, which was empowered to "establish and equip with the proper and necessary apparatus, instruments, and supplies a state laboratory of hygiene for the chemical and bacteriological examination of water supplies, milk, and food products, and the examination of cases and suspected cases of diphtheria, typhoid fever, tuberculosis, glanders, and other infectious and contagious diseases".

With the establishment in 1917 of the Public Utilities Commission law and control, an informal working agreement was made with the Public Utilities Commission, whereby the Sanitary Engineering Division laboratory, created under the reorganiza-

tion act from the Laboratory of Hygiene, would make chemical and bacteriological tests of public water supplies and report the results to the Public Utilities Commission as well as to the water utilities, and this has substantially continued until the end of the past month when the new law became effective.

Another factor of great importance during this period was the development by the United States Public Health Service of a working standard for evaluating the quality of water supplies for interstate carriers, and this standard as developed in 1914 gradually became the basis on which the safety of municipal water systems was evaluated. A part of the legislative changes in 1917 was a reorganization of the activities of the State Laboratory of Hygiene with the creation of a Division of Sanitary Engineering, which still retains the laboratory functions of making bacteriological and chemical analyses of public and private water supplies, as well as other analytical duties, and with them the inspection of water supplies for interstate carriers. As these involved the use of the interstate water standard, it wasn't long before it was seen that many of the Maine water systems as they were being operated did not meet these standards.

Under the guidance of the late Sanitary Engineer, Walter Brennan—incidentally a ball-player of local fame—the State Department of Health adopted rules and regulations relating to public water supplies, which included the Public Health Service standard for interstate carriers as a requirement for Maine public water supplies. This became effective on December 1, 1922. Mr. Brennan left the employ of the state to become superintendent of the Woodland Light & Water Company in January, before the new regulations could be put into effect, and so the speaker was presented with the problem of applying a new standard and regulations when he came to the Department in February of that year.

Vigorous action was taken to improve the quality of the various supplies, hoping by more emphasis on the promotion of safe public and semi-public water supplies to improve the economy of the state with increased travel and the development of the tourist and recreational business. The development of practical methods of sterilization by means of liquid chlorine, replacing the more cumbersome use of calcium hypochlorite which had

previously been about the only practical sterilizing agent, made this possible. Although the use of chlorine as a sterilizing agent really started in Maine in 1916 (Kennebunk), progress in sterilization was very slow, the record showing one only in 1917, but three in 1918 and five in 1919, six in 1920, five in 1921 and two in 1922. Following the adoption of the new regulations and efforts to secure compliance with them, 31 municipal systems installed chlorine treatment plants in the 1923 season. The installation of similar treatment plants since that time has been steady and commensurate with the development of new water systems, most years seeing a number of installations.

Since a great majority of public water systems derive from lakes or upland streams, there has been little need for filter plants, and generally the improvements gained by such systems are hardly commensurate with the necessary expenditures. At the present time there are in existence 3 slow sand filter plants, 14 rapid sand, 5 pressure rapid sand, and one softening plant. A total of 118 use chlorine or hypochlorite; in all cases those having filter plants use chlorine or hypochlorite treatment as a part of the purification system.

More recently a new development in the field has been the agitation for application of fluorides to municipal water systems. This has been rather a controversial matter which, however, does not need to enter into discussion as a part of this talk, except to indicate that after much and vigorous agitation, pro and con, three Maine towns are now applying fluorides to their municipal systems. Norway, using sodium silicofluoride, started in 1952; Brunswick and Woodland, using granular sodium fluoride, in 1955. The city of Bangor in January, 1955, started to use hydrofluosilicic acid but decided to discontinue this material in October of the same year. Through special legislation in 1951 the Division of Sanitary Engineering of the State Department of Health and Welfare was made the agent for supervising the treatment of municipal water supplies with fluorides and has been operating under this special act since that time.

In essence, it would appear that we have reviewed much of the progress and accomplishments in the past 75 years and slightly before. Incidentally, the records are meager and in many cases inaccurate. We have found sometimes that the dates of

beginning of these water systems refer to legislative authorization and in some cases to the dates of actual construction, which may be a few years apart. A more exhaustive search of the records can be expected to improve this data, but I hope this has been interesting and gives a word picture of the water-works progress in Maine. Although many small water systems have been started and served their usefulness, some of which have simply worn out and been discontinued, and others have been absorbed into larger water utilities, there is still practically the same total number of water utilities in present use as at any time during the period covered by this discussion.

The present records indicate 165 municipal water utilities operating in the state, with 201,551 service connections, serving an estimated population of 604,653 people.

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APPENDIX I

HISTORICAL LIST OF MAINE WATER UTILITIES

CODE

Source of Supply

L — Lake
W — Well
SP — Spring
B — Brook
R — River
GR — Gravel-Packed Wells
INF. GAL — Infiltration Gallery

Method of Supply

G — Gravity
P — Pumped

Treatment

Cl — Chlorine
RS — Rapid Sand
SS — Slow Sand
PS — Pressure Type, Rapid Sand
NT — No Treatment
Z — Zeolite
F — Fluoride
AMM — Ammonia

1830	Central Aqueduct, Skowhegan	SP — G, Disc. 1943
1836	Skowhegan Aqueduct	SP — G
	Skowhegan Water Co.	SP — P — RS — CL 1918
	West Skowhegan	SP — G — CL 1935
1850	Bingham (Folsom)	SP — G
1860	Hillside, South Paris	W — G
1865	Crystal Fountain Aqueduct, South Paris	W — G
1867	Quantabacook, Harrington	SP — G
1868	Portland	L — G — CL 1921
1869	Auburn	L — P — CL 1923
1872	Cherryfield	W or SP — G
1874	South Paris Crystal Fountain Aqueduct Assoc.	Disc.
1875	Bangor	R — P — RS — CL 1919 New Source Voted 1957 — L
	Bar Harbor	L — G — SS 1905 — 1906 — Not used since 1914 — 3 Units — CL 1932 — Booster Pumps — Amm. 1928
1877	Coburn Aqueduct, Skowhegan	SP — G
1878	Lewiston	L — G & P — CL 1923
	Milbridge	SP & W — G
	Springvale	L — P — SS — CL 1924 (Sold to Sanford)
1879	Pine Tree Aqueduct, South Paris	Dr. W's — P

APPENDIX I (*continued*)

1891	(See 1893)	
1882	Fryeburg	B — G — CL 1923
	Acadia — Aqueduct to Castine	SP — G Now part of Castine Water Company
1883	Northeast Harbor	L — P — CL 1935
1884	Biddeford and Saco	R — P — RS — CL 1923
1885	Gardiner	R — P — SS — CL 1923
	Rockland	L — G — CL 1923
	Hancock	W — P
	Houlton	B — P — CL 1919 — Aux. Gr. W 1940
	Dover-Foxcroft — Blethen House Spring Water Co.	SP — G
1886	Norway	L — P — CL 1923 — Silico — F — 1955
	Augusta	L — G & P — CL 1923 — Lime — Amm — Aux. L — P — CL (Aux. Gravel Packed Wells, 1956)
	Brunswick	W — P — CL 1923 — Amm. 1940 — FL 1955
	Calais	W — P — CL 1922 — Aux. R — P — RS — CL
	Sorrento, Long Pond	L — G
	Richmond	R — RS — P — CL 1921 — New Supply Gr. W. 1956
1887	Presque Isle	R — RS — P — CL 1918
	Sanford	W's & SP's — P — CL 1923 — PS
	Waterville	L — G — CL 1923
	Caribou	P — (CL 1917 Electric Bleach Gas Co.) W & T 1920 — RS 1945
	Bath	L — P — CL 1924 — Aux. B
	Dover-Foxcroft	L — G — CL 1918 — Aux. R — CL New Source 1936
	Belfast	R — P — RS — 1912 & 1913 — CL — 1923
1888	Eastport	R — P — CL 1923
	Ellsworth	R — P — CL 1923
1889	Fort Fairfield	B — P — CL 1921 — Aux. B — G — CL 1938
	Oakland	L — P — CL 1923
	Bethel	B — B — CL 1944
	Old Town	R — RS — P — CL 1920

APPENDIX I (*continued*)

1890	Veazie	R — RS — P — CL 1923
	Orono	R — RS — P — CL 1923
1891	Winter Harbor	L — P (Hypo)
	Northport	SP & W — P
	Madison	L — G — CL 1931
	Freeport	B — P — CL 1923
1893	Patten	SP — G — W — P
	Rumford	B — G — CL 1923
	Small Point	L — P — CL 1926 — PS
	South Berwick	R — P — CL 1923 — RS
	Southwest Harbor	L — G — CL 1941
	Farmington	L — G
1894	Newport	L — G — CL 1926
	Pittsfield	W's — P — CL 1923
	Boothbay Harbor	L — P — CL 1923
	Seal Harbor	L — G — Hypo
1895	Lamoine Beach — Cold Spring	S — P
	Mechanic Falls	R — RS — CL 1919
	Union	SP & W — P
	Yarmouth	SP — P — CL 1920 — Aux. River
	Castine	W's & SP's — P
1896	North Berwick	B — RS — P — CL 1919
	Kennebunk, Kennebunkport and Wells	B — P (Pr. R.S) — CL 1916
	Machias	R — P — CL 1920
	Winterport	L — P — CL 1923
	York	L — G — Amm. & CL 1939
	Damariscotta	L — P
	Milbridge Water Co.	SP. & W — P
1897	Wilton	L — P — Hypo 1950
	Warren	W & SP — G
	Friendship	W & SP — P — Summer — G in Winter
	Lamoine Beach	L — G
	Brooks	DW & SP
	Bucksport	L — G — P — RS — CL 1939
	Kingfield	B — G — CL 1926
	Roberge, Joseph	SP — P
	Monson Spring	SP & W's — P
1898	Acadia Aqueduct, Castine	SP — G
	Hallowell	L — P — CL 1923
	Phillips	L — G — CL 1950
	Mexico, Chase, Joseph	SP — G

APPENDIX I (*continued*)

1899	Scarboro	L — Absorbed by Portland Water District
	Paris Hill	W's — P
1900	Livermore Falls	L — G — CL 1923
	Hebron	L — G — Hypo — CL 1930
	Stratton	SP — G — Hypo 1940
	Winthrop (L. T. Carleton)	2 W's — P — changed to Winthrop Water District 1925 plus CL
1901	Abbot, Mexico	SP — P — Disc.
	Kezar Falls	W — P
	Millinocket	L — P — RS — CL 1927
	Berwick	SP — W — P — CL 1923 — Aux. R — P
	Bridgton	L — P — CL & Amm. 1923
1902	Lubec	W — P — CL 1920 (Aux. Gr. W. 1957)
1903	Dexter	L — P — CL 1923
	Jefferson, Merserve	SP — G
	Strong	L — G — CL 1927
	Van Buren	B — P — CL 1923
1905	Rangeley	B — G — CL & Amm. 1940 — Aux. L — P
	Sullivan Harbor	L — G
	Buckfield	L — G
1906	Stockton Springs	L — G
	Searsport	L — G — Aux. — Gr. W. 1941
	Woodland	R — RS (Pressure — R.S. — CL 1922)
	Danforth	W — P — Aux. R — CL 1935
	Dixfield	B — G — CL 1928 — Aux. L
	North New Portland	SP — G
	E. Brownfield, J. E. Clement	W — P
1907	Steep Falls	SP — P
	Morrill	W — P
1908	Smith & Green, Rumford	SP — G
	Limerick	SP & W — G & P — CL 1938
	Brownville	2 SP's — G — W — P
	Brownville Junction	SP & W — P & G — CL 1919 On Aux. — R — P
	East Millinocket	R — P — CL 1928 — (Aux. Gr. W 1940 Now Main Source)
	Cumberland Center	W & SP's — G & R — Hypo 1934
	Eustis	SP — G

APPENDIX I (*continued*)

	Kittery	L — G — CL 1940 — (Aux. Gr. W 1942)
	Mexico	G — G — CL 1926 — (Aux. W CL 1931)
	Greenville, Mabel Hart	W — Flowing
1909	Andover	B — G — CL Hypo 1935
	Farmington Falls	SP — W — G & P
	Milo	R — P — CL 1920
	South Paris	B — G — SP — CL 1921 — Gr. W 1936
	Saint George (Port Clyde)	W — P
	Weeks Mills	SP — G — Hypo
	Stonington	L — P — Hypo
	Lisbon Falls	W — P
1910	Sangerville	L — P
	Waldoboro	W — P
	West Falmouth	SP — G — Disc.
	Westfield	SP & B — Abandoned 1948
	Belgrade	L — P — CL 1923
	Guilford	L — G — Hypo 1935 — P
	Island Falls	B — P — CL 1924
	North Bridgton	SP — G
	Peaks Island	L — G — Absorb. by Portland Water District
	Vinalhaven	L — P — (Hypo Disc.)
1911	Allen, Columbia Falls	SP — G
	Cornish	SP — P
	Hartland	L — G — Hypo 1940 ±
	Jackman	SP — G — L — P — CL on Lake 1921
	North Haven	L — P
	Mars Hill	L — G — Hypo
	New Sharon	W — P & G
	Bingham	L — G — CL 1938
	South Paris, Peoples Water Co.	W — P
	Alfred	L — P — CL 1931
1912	Norridgewock	B & SP — G
	Lincoln	L — G — CL 1939
	Limestone	B — P — CL 1926
1913	Greenville Water Co.	L — G — Hypo 1933
1914	East Vassalboro	R — P — Hypo
	Monhegan	W — P
	Fort Kent	B — G — CL 1923 (Aux. Stream)

APPENDIX I (*continued*)

1915	South Freeport	SP — G & P
1916	Anson	L — CL Hypo
	Wiscasset	B — P. Filters 1920 — P — CL 1923 PS
	Washburn	W — P
1923	Southport	L — P — CL 1939
1925	Winthrop Water District (Includes I. T. Carleton System 1900)	L — P — CL 1925
1926	Lucerne	L — G — Hypo
1927	Canton, Lyman Smith	L — P — Hypo 1932
1929	Gray	SP — P — Hypo — CL 1938
1931	Madawaska	R — P — CL 1931
1933	Columbia Falls — Crandon	SP — G
1934	Howland	R — P — CL 1935
1935	Harrison	L — P — Hypo 1935
	Seal Cove	L — P — CL 1935
	New Harbor	W — P
	Windham	W — P — Now Portland Water District
1937-38	Hampden	R — P — SS — Hypo 1938 (Gr. W. 1956)
	North Windham	L & W's — Hypo CL 1938
1942	Searsmont	SP — G
1947	Clinton	Gr. W. — P — CL — Softener
	New Gloucester	W — P
	North Jay	Gr. W — P — Aux. quarry CL
1949	Ashland	R — RS — P — Hypo CL 1945
1950	Brewer Water District	L — P — CL
1950-51	West Paris Water Department	W — P — Hypo 1950

APPENDIX I (*continued*)

ACTIVE LIST OF MAINE WATER UTILITIES (1957)

CODE

D — District (Quasi-Municipal)
M — Municipal
P — Privately Owned

Name of company	*Code*	*Superintendent*	*Address*	*No. of customers*
Addison Point Water District	D	M. H. Brown, Chairman	Addison	50
Alfred Water Co.	P	John B. Donovan, Gen. Mgr.	Alfred	
Allen Water Co.	P	Bion B. Tibbetts, Manager	Columbia Falls	
Andover Water Co.	P	Raymond Akers, Pres.	Andover	230
Anson Water District	D	William E. Hartwell	North Anson	507
Ashland Water District	D	Eugene A. Orcutt	Ashland	217
Auburn Water District	D	L. K. Parker	Auburn	7,032
Augusta Water District	D	Sidney S. Anthony	Augusta	6,965
Bangor Water District	D	Donald P. Johnson	Bangor	10,275
Bar Harbor Water Co.	P	T. W. Grindle	Bar Harbor	1,298
Bath Water District	D	M. A. Libby	Bath	3,209
Belfast Water District	D	H. E. Blanchard	Belfast	1,281
Belgrade Power Co.	P		Belgrade	
Berwick Water Department	M	Paul J. Flynn, Manager	Berwick	
Bethel Water Co.	P	E. A. Van Den Kerckhoven	Bethel	317
Biddeford & Saco Water Co.	P	Wilbur H. Dewey	Biddeford	9,298
Bigney, F. R.	P		Greenville	
Bingham Water District	D	Donald Folsom	Bingham	355
Blethen Spring Water Co.	P	A. P. Stacy, Owner	Dover-Foxcroft	
Boothbay Harbor Water System	M	Chester A. Swett, Manager Albert Howard, Supt.	Boothbay Harbor	1,970

APPENDIX I (*continued*)

Name of company	*Code*	*Superintendent*	*Address*	*No. of customers*
Brewer Water District	D	Hartley E. Rider, Manager	Brewer	2,203
Bridgton Center Village Corp. Water Department	M	Everard Wentworth	Bridgton	559
Brooks Water Co.	P	Albert Payson, Owner	Brooks	
Brownville Junction Water Dist.	D	Reginald Call	Brownville Jct.	326
Brownville Water District	D	Charles Foulkes, Chairman	Brownville	
Brunswick & Topsham Water Dist.	D	E. Boyd Livesay	Brunswick	3,680
Buckfield Water Department	M	Ernest Buck	Buckfield	161
Bucksport Water Co.	P	G. Winslow Weston	Bucksport	575
Calais Water & Power Co.	P	Ralph H. Eagan	Calais	1,935
Camden & Rockland Water Co.	P	Allan F. McAlary	Rockland	6,252
Canton Water Co.	P	Lee C. York	Canton	78
Caribou Water Works Corporation	P	K. P. Currier, Manager	Caribou	1,862
Castine Water Co.	P	Mrs. W. H. Owen, Pres. Paul Marckoon, Supt.	Castine	282
Clinton Water District	D	Frank E. Besse, Manager	Clinton	243
Coburn Aqueduct Co.	P	Blin W. Page	Skowhegan	
Cold Spring Water Co.	P	Ray Smith	R.F.D. No. 2, Ellsworth	
Cornish Water Co.	P	Clarence A. Small	Cornish	210
Crandon, M. E.	P		Columbia Falls	
Cumberland Center Water Co.	P	Gerald Packard, Pres.	Cumberland Center	196
Damariscotta-Newcastle Water Co.	P	Paige B. Rand, Manager Mrs. Kathryn Stuart, Pres.	Damariscotta	549
Danforth Water District	D	George W. Golding, Trustee & Supt.	Danforth	130
Dexter Water Works	M	C. S. Brewster	Dexter	831

APPENDIX I (*continued*)

Name of company	*Code*	*Superintendent*	*Address*	*No. of customers*
Dixfield Light & Water Co.	P	Frank M. Bryant	Dixfield	357
Dover & Foxcroft Water District	D	Kenneth J. Field	Dover-Foxcroft	879
Eastport Water Co.	P		Eastport	941
East Vassalboro Water System	P	Herman Masse, Manager	East Vassalboro	
Farmington Falls Water Co.	P	Robert A. Crosswell, Director	Farmington Falls	50
Farmington Village Corp.	M	Frank T. Adams	Farmington	1,284
Fort Fairfield Utilities Dist.	D	Howard McCue	Fort Fairfield	697
Fort Kent Water Co.	P	Richard A. Nadeau	Fort Kent	539
Freeport Water Co.	P	M. A. Crooker	Freeport	406
Friendship Water Co.	P	E. E. Jameson, Owner	Friendship	
Fryeburg Water Co.	P	Francis Wentworth	Fryeburg	391
Gardiner Water District	D	George Webb	Gardiner	3,334
Gray Water District	D	Earle Watson	Gray	275
Greenville Water Co.	P	Ernest Harrington	Greenville	383
Guilford Water Co.	P	Alvin McDonald	Guilford	453
Hallowell Water District	D	George Robinson	Hallowell	854
Hampden Water District	D	Paul M. Nickerson	Hampden	828
Hancock Water, Light & Power Co.	P	Harry W. Johnston	Hancock Point	17
Harrison Water Co.	P	E. W. Davis, Treasurer	Harrison	626
Hartland Water Co.	P	H. E. Randlett	Hartland	340
Hebron Water Co.	P	Claude L. Allen, Jr., Pres.	Hebron	24
Highland Water Co.	P	Lawrence K. Hall, Manager	Greenville	
Houlton Water Co.	M	Paul W. Coleman	Houlton	1,911
Howland Water Department	M	James Currie, Town Agent Charles Davis, Operator	Howland	350
Island Falls Water Co.	P	Paul Jones	Island Falls	259

APPENDIX I (*continued*)

Name of company	*Code*	*Superintendent*	*Address*	*No. of customers*
Jackman Water, Light & Power Co.	P	Hector Ferland	Jackman	314
Kennebec Water District	D	J. Elliott Hale	Waterville	9,256
Kennebunk, Kennebunkport & Wells Water District	D	L. G. Smith	Kennebunk	5,171
Kezar Falls Water Co.	P	William A. Garner, Gen. Mgr.	Kezar Falls	331
Kingfield Water Co.	P	Earl Wing, Manager	Kingfield	105
Kittery Water District	D	Francis L. Hatch	Kittery	3,725
Lamoine Beach Water Co.	P	Arthur Vidito	Lamoine Beach	
Lewiston Water Department	M	George J. Maher, Director, P.W.	Lewiston	13,020
Limerick Water Co.	P	Henry H. Eastman	Limerick	182
Limestone Water & Sewer Co.	P	K. P. Currie	Caribou	411
Lincoln Water District	D	Clifford W. Williams	Lincoln	678
Lisbon Water Works	M	Arthur Plummer, Chm. of Board	Lisbon Falls	1,070
Livermore Falls Water District	D	Cecil Mann	Livermore Falls	1,356
Long Pond Water Co.	P	A. L. Whipple	Sorrento	105
Lubec Water District	D	J. W. Bate	Lubec	747
Lucerne Water Co.	P	John H. McTague	Lucerne-in-Maine	41
Machias Water Co.	P	Hartley Crane	Machias	539
Madawaska Water District	D	Roger J. Berube, Chairman Fernand Maquise, Supt.	Madawaska	863
Madison Water District	D	Archie Maslen	Madison	878
Mars Hill & Blaine Water Co.	P	K. P. Currie, Manager (Caribou)	Mars Hill	597
Mechanic Falls Water Co.	P	Arnold Williams	Mechanic Falls	457
Meserve, J. Y.	P		Jefferson	
Mexico Water District	D	Harold McInnes	Mexico	1,154
Milbridge Water Co.	P	Willis Hinkley Wm. S. Sawyer, Pres.	Milbridge	188

APPENDIX I (*continued*)

Name of company	*Code*	*Superintendent*	*Address*	*No. of customers*
Millinocket Water Co.	P	Henry Michaud	Millinocket	1,445
Milo Water District	D	Bion F. Jose, Town Manager	Milo	664
Monhegan Water Co.	M	Ferdinand L. Day, 1st Selectman	Monhegan	
Monson Spring Water Co.	P	Esmond Richardson	Monson	117
Morrill Water Co.	P	A. D. Hatch, President	Morrill	
Moscow Water District	D	Donald Folsom	Moscow	96
New Harbor Water Co.	P	R. M. Search, President	New Harbor	94
Newport Water Co.	P	W. A. Getchell	Newport	492
New Sharon Water Co.	P	C. A. Thompson, Owner	New Sharon	58
Norridgewock Water District	D	Emmons Casey, Treas.	Norridgewock	206
North Berwick Water Co.	P	Howard LaBreck	North Berwick	349
North Bridgton Water Co.	P	Hursel Ryerson, Pres.	North Bridgton	71
North Haven Water System	M	Vernon L. Beverage, Manager	North Haven	229
North Jay Water District	D	Lynn Miller, Manager	North Jay	103
North Village Water Co.	P	Clayton J. Upton, Manager	No. New Portland	55
Northeast Harbor Water Co.	P	Maurice H. Burr	Northeast Harbor	478
Northern Water Co.	P	Arthur W. Haskell	East Millinocket	523
Northport Spring Water Co.	P	Clyde Howard	Northport	209
Norway Water District	D	A. G. Blaquiere	Norway	967
Oakland Water Co.	P	Ned Small	Oakland	587
Old Town Water District	D	William P. Jenkins	Old Town	3,052
Paris Hill Water Co.	P	George Hammond	Paris	92
Patten Water District	D	Irving H. Bragg, Chairman	Patten	106
Penobscot County Water Co.	P	E. A. Ray	Ellsworth	2,250
Penobscot County Water Co.	P	J. M. Murray, Manager	Orono	
Phillips Water Co.	P	Conrad Gould	Phillips	333

APPENDIX I (*continued*)

Name of company	*Code*	*Superintendent*	*Address*	*No. of customers*
Pine Tree Aqueduct Co.	P	Mrs. E. N. Haskell	South Paris	27
Pittsfield Water Works	M	O. Lionel Pomroy, Town Agent	Pittsfield	948
Porters Landing Water District	D	Myron D. Hilton	Freeport	
Portland Water District	D	Herman Burgi, Jr., Gen'l Mgr.	Portland	45,033
Presque Isle Water District	D	Douglas Dingwall	Presque Isle	1,604
Puiia, Nicholas J. Water Works	P		Rumford	
Quantabacook Water Co.	P	Jasper Lee	Harrington	
Rangeley Water Co.	P	A. Mason Russell, Manager Walter Anderson, Supt.	Rangeley	319
Richmond Water Works	P	Richard N. Berry, President Clinton Hinkley, Supt.	Richmond	483
Rumford Water District	D	G. G. Tardiff	Rumford	2,487
Sabbathday Lake Water Works	P	D. C. Wilson, Manager	New Gloucester	
Sanford Water District	D	E. S. Littlefield, Jr.	Sanford	4,985
Sangerville Water Supply Co.	P	Howard Butcher, President	Sangerville	186
Seal Cove Water Co.	P	Elbert Hodgdon	Seal Cove	53
Seal Harbor Water Co.	P	Edward K. Dunham, 3rd, Pres.	Seal Harbor	267
Searsmont Water Co.	P	E. O. Sprowl, Owner	Searsmont	
Searsport Water District	D	Donald W. Vaughan, Mgr.	Searsport	427
Skowhegan Water Co.	P	Donald Brunell, Manager	Skowhegan	1,412
Small Point Water Co.	P	W. A. Blair	Small Point	29
South Berwick Water Corp.	P	Albert Watkins	South Berwick	680
South Freeport Water District	D	M. A. Crooker	South Freeport	117
So. Paris Village Corp. Water W.	M	Solomon N. Gay, Supt.	South Paris	846
Southport Water System	M	R. Stewart Thompson	Southport	
Southwest Harbor Water Co.	P	Donald Sullivan	Southwest Harbor	422

APPENDIX I (*continued*)

Name of company	*Code*	*Superintendent*	*Address*	*No. of customers*
St. George Water Co.	P		Port Clyde	92
Stockton Springs Water Co.	P	Bert Bowden	Stockton Springs	201
Stonington Water Co.	M	Arnold C. Brown, Town Manager	Stonington	231
Stratton Water Works	P	A. B. Sargent, Owner	Stratton	134
Strong Water District	D	A. D. Pratt	Strong	155
Sullivan Harbor Water Co.	P	Sidney E. Doyle, Supt. T. E. Jewell, Treasurer	East Sullivan	39
Union Water Co.	P	Philip Morine, Manager	Union	77
Van Buren Water District	D	Louis Dumais, Supt. Louis Parent, Town Manager	Van Buren	898
Vinalhaven Water Co.	P	A. A. Peterson, Manager	Vinalhaven	330
Waldoboro Water Co.	P	Fred Harris	Waldoboro	234
Warren Water Supply Co.	P	Howard L. Norwood, Manager	Warren	218
Washburn Water Co.	P	Donald Maskell	Washburn	281
Weeks Mills Water System	P	William Thomas	Weeks Mills	
West Paris Water Dept.	M	E. C. Ellingwood, Commissioner	West Paris	102
West Side Aqueduct Co.	P	Clayton E. Tucker, Treasurer	Cherryfield	
West Skowhegan Aqueduct Co.	P	Bert B. Harvell	Skowhegan	81
Wilton Water Co.	P	Lybrand C. Goldsmith	Wilton	883
Winter Harbor Water Co.	P	Albert Hallowell	Winter Harbor	182
Winterport Water Co.	P	K. C. Nealley	Winterport	269
Winthrop Water District	D	E. A. Tarr	Winthrop	702
Wiscasset Water Co.	P	Paige B. Rand Byron Adams, Operator	Damariscotta	332
Woodland Water & Electric Co.	P	Robert Hackett	Woodland	417
Yarmouth Water District	D	Myron Estabrook	Yarmouth	1,120
York Water District	D	James H. Lucas	York	2,291

APPENDIX II

RULES AND REGULATIONS OF THE STATE DEPARTMENT OF HEALTH RELATING TO PUBLIC WATER SUPPLIES

Section 1. Under authority conferred by Chapter 197, Laws of State of Maine 1917, as amended by Sec. 14 of Chapter 172 of Laws of 1919, the following rules and regulations are hereby made by the State Department of Health to be in effect on and after December 1, 1922.

Section 2. The water furnished for public use by any municipality, company, corporation, institution or person, shall be of such quality as not to injure the health of those using same. Its bacteriological purity shall be such as is required by the United States Treasury Department, Public Health Service for drinking water supplied to the public by interstate carriers. It shall contain no chemical impurities which are likely to cause disturbances in the human system.

Section 3. No owner, agent, manager, operator or any one having charge of any water works furnishing water for public or private use, shall knowingly permit the appliances of the same to become in a filthy condition, or in such a condition that the purity and healthfulness of the water supplied by reason thereof shall become dangerous to public health.

Section 4. When the examination of any public or private water supply shows pollution whether chemical or bacteriological, which makes the water unsafe for domestic use, the owner, agent, manager, operator or any one having charge of any water works furnishing this water shall, when so notified, within time specified by the State Department of Health, take steps to remove and prevent this pollution, and make such changes as may be necessary to safeguard the public health as the Department of Health may require.

Section 5. The term "water works" used in these rules and regulations is defined under Sec. 15, Chap. 55 of Revised Statutes of State of Maine.

Section 6. The term "water supply" used in these rules and regulations shall be construed to mean and include water that shall have been taken into water works as hereinbefore defined from all streams, springs, lakes, driven wells, artesian wells, surface waters or any other source natural or impounded and the tributaries thereto.

Section 7. The State Department of Health reserves the right to make such revisions of these Rules and Regulations, as it may deem necessary from time to time.

Approved by the Public Health Council, November 29, 1922.

Under authority conferred by Section 8 of Chapter 22 of the Revised Statutes of 1944 the standards relating to Public Water Supplies approved by the Public Health Council, November 29, 1922 are hereby repealed and the following drinking water standards for public, semi-public and private water supplies are hereby adopted by the Advisory Council of Health and Welfare.

1. In any single standard sample, bacteria of the coliform group (B. Coli) shall not be present in more than one of the five standard ten milliliter (10 ml.) portions tested in lactose broth.

2. Of all the standard ten milliliter (10 ml.) portions examined per month in accordance with the specified procedure, not more than ten per cent (10%) shall show the presence of organisms of the coliform group.

3. The procedure for the bacteriological examination of water shall be as outlined in the "Standard Methods for the Examination of Water and Sewage", latest edition.

Approved by the Advisory Council of Health and Welfare April 24, 1946.

1957 PUBLIC LAWS OF MAINE

CHAPTER 269

AN ACT RELATING TO SYSTEMS OF WATER SUPPLY

Section 1. R.S. c. 25, 3 amended. Section 3 of Chapter 25 of the Revised Statutes is hereby amended by adding at the end thereof, a new paragraph, to read as follows:

'The Department shall consult with and advise the authorities of municipalities and persons and corporations having, or about to have, systems of water supply, as to the most appropriate source of water supply and the best method of assuring its purity, and all such authorities and persons shall submit to the Department for its advice, their plans and specifications for all new systems of water supply and all new purification plants, and for any replacement of a major portion of an existing system of water supply or purification plant, before installing or replacing such facilities, but they shall not be required to submit to the Department for such advice any proposed repair, alteration, relocation or extension of their existing systems of water supply.'

Section 2. R.S. c. 25, 141 amended. Section 141 of Chapter 25 of the Revised Statutes is hereby amended to read as follows:

'Section 141. Samples for examination of water sold for domestic purposes; if polluted; cost; inspection. The Department may require any person, firm, corporation, municipality or water district selling water for domestic purposes to furnish samples thereof for chemical and bacteriological examination, and if said water is found to be contaminated, polluted, and unfit for domestic use, the Department may issue an order prohibiting the transporting, sale, distribution or supplying of such water as long as such contamination, pollution, and unfitness remains, and may issue an order directing the installation and operation of such purification equipment as may be reasonable and proper, and may make reasonable rules and regulations for the adequate operation of all water purification equipment.

Representatives of the Department may enter upon the premises and inspect any water purification equipment to determine compliance with the law, Department orders and Department rules and regulations. Any person, firm, corporation, municipality or water district required under the provisions of this section to furnish samples of the water sold or to be sold by it for domestic purposes shall pay the shipping charges thereon, and the Department shall charge the average cost of the analysis for such examination to the person, firm, corporation, municipality or water district required to have such tests made.'

HISTORY OF WATER SUPPLIES IN NEW HAMPSHIRE
1882 - 1957

BY WILLIAM A. HEALY*

[Read September 18, 1957.]

In preparing this short summary of water-works progress in New Hampshire over the last several years, I was fortunate to have a complete set of State Board of Health biennial reports at my disposal. These volumes contain a very complete record of water-supply development throughout the period of the Board's existence, and naturally I have relied upon them heavily.

As would be expected, at the outset the Board recognized the vital importance of providing clean and ample sources of water. However, its authority to control water systems was extremely limited. Likewise, it had very little in the way of funds and personnel to investigate matters dealing with water supply. The same handicaps restricted the activities of the Board in other areas of public health work. Hence, for the most part, its efforts were necessarily directed toward educational campaigns, designed to inform the public concerning matters dealing with the protection of health. What limited resources the Board had were largely concentrated in coping with the numerous outbreaks and epidemics of typhoid fever, diphtheria, smallpox, scarlet fever and other communicable diseases which occurred with great frequency. I can well appreciate the difficulties and frustrations that must have accompanied their efforts, which, of course, had to be handled by mail or other slow means of communication then available.

So far as records show there were, even at the time of the Board's establishment, a number of public water-supply systems in the State. I believe the first one of any significant importance to be established was the Pennichuck Water Works in 1852, the supply for the city of Nashua. Other larger cities such as Concord and Manchester developed public systems in the early 1870's. The numerous small systems which came into existence

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throughout the State, particularly during the late '80's and early '90's, as a result of community growth, were often financed by private interests. Later many of these were purchased and operated by the municipality itself. For the most part, the source of supply in such cases consisted of groups of springs and wells with gravity flow to the distribution system. Pumping was avoided as much as possible because of the obvious expense, and treatment of any sort was rarely applied. These developments served to improve the situation somewhat with respect to the transmission of water-borne disease, because they permitted abandonment of many individual wells which were polluted. However, it was certainly far from the complete answer, as is witnessed by the following which is quoted from the Board report of 1897-98:

> " . . . But small communities and even large villages sometimes proceed in a short-sighted and blundering way. Having scanty resources at best, often relying upon local talent as sufficient to plan and construct such apparently simple works as a mere pipe line from some spring, pond, or brook, or a plain system of drainage, and acting upon the principle, 'If there is any profit in it, we want to make it', they use up their small capital, only to obtain at last, works which are either inadequate or defective, if not partial failures. They realize too late, that such questions as a proper source of supply, a possible gravity feed, as against the ever expensive pumping system, the probable future demand, storage capacity for dry seasons, various desirable uses, size of pipe (considering possible demands of fire service and allowance for rust or other deposit), loss of pressure due to flow, blow offs, grades, gates for controlling the line in emergencies, that these and not a few other questions call for special knowledge and experience. A few hundreds of dollars spent for surveys and expert opinion may save many times the expense, either in mistakes avoided, or larger results obtained. Communities in New Hampshire would be fortunate if they were compelled by law, as in Massachusetts, to consult the state board of health, and have the merits of all plans passed upon.
>
> "But the lack of public appreciation of the public benefit of such a policy, and the fact that it would call for some increase in appropriations, render it unlikely that our state board will be able to render such service, to its proper extent, for some time to come."

Shortly thereafter in 1899, because of the continued development of lake sources for public water supply, the Legislature granted the Board authority to promulgate rules and regulations, aimed at the protection of such waters against pollution considered to be dangerous or inimical to the health of the

consumer. Over the years many such regulations, restricting conflicting uses in lakes utilized for public water-supply purposes, have been adopted, and today there are some 36 supplies in this category which are protected by regulations.

In common with experience elsewhere, typhoid and epidemics of other intestinal illnesses occurred as a result of contaminated water supplies, in the early 1900's. This is not surprising when we consider the lack of adequate treatment and the absence of sanitary control which existed at that time. Some of the larger lakes which were utilized for a supply supported a great variety of recreational uses as well, and the eventual result of this arrangement is obvious to you. Conditions were even more critical when rivers in populated areas were utilized, either directly or after ineffective filtration through crude filtration works. Facilities such as these were responsible for the most serious typhoid epidemics in the history of the State. These occurred at Woodsville and Littleton in 1900 and 1904.

Over-all, however, the water-supply picture in New Hampshire was considerably brighter than in many of the other states. For one thing the population was relatively small with respect to other states, and there was an abundance of upland streams and lakes of excellent quality and quite remote from important sources of pollution. These were readily available, and many communities took advantage of such sources. Despite the lack of treatment, these could be, and were, employed in many instances for water supply with little or no serious danger to the public.

Beginning in 1902, with the establishment of laboratory facilities, the State Board of Health was able to make its first serious attempts toward the development of a sanitary control program for public water supplies. Regular sampling procedures were introduced, followed somewhat later by a system of routine watershed inspections. The Board also discouraged use of lead pipe in these early years. Of major importance was the gradual disappearance of dual use of supplies for recreation and drinking-water supply. This was due to the severe restrictions imposed by the Board and the growing public sentiment in favor of clean and protected water supplies.

The more progressive cities long ago adopted the policy of buying up shore properties and re-foresting the watersheds. This

has been a significant step in the right direction, and notable examples of this approach can be found in Manchester, Concord and Nashua. On the other hand, there have been some communities which did not exhibit similar foresight, and these have had to either abandon the surface supply in favor of a ground source, because of the constant encroachment by recreational properties, or install more radical treatment facilities to insure safe quality. Today we are experiencing a resurgence of the dual-use theory, and pressure is being exerted in efforts to open lake sources to recreational activity, on the assumption that existing treatment facilities are adequate to remove the inevitable contamination which results. The fact is that water-supply management has been able to maintain an enviable record in the prevention of water-borne disease by careful control over watershed uses, and it would be unfortunate if this policy were to be seriously threatened. I believe this Association has established a committee to survey and study the problem of conflicting water uses, and I am sure that the results of its efforts and recommendation will be an important guide in this matter.

The New Hampshire Board followed with great interest the results of the studies performed at the Lawrence Experiment Station, and thus the filter plant constructed at Somersworth in 1913, to filter water from the Salmon Falls River, was designed on the basis of the Lawrence Experiment Station experience, and it is said to be the second such installation made in the country. Chlorination was first applied in New Hampshire in the city of Laconia in 1912, and naturally the practice has grown under the Board's policy of requiring this as a minimum form of treatment for all surface supplies in the State. Of the existing 63 surface-water sources, all except 11 are now provided with at least chlorination, and about 9 receive further treatment by either rapid or slow sand filtration.

Of considerable assistance throughout this program for water-supply improvement has been the 1913 law which provides that, before any new supply may be adopted or extensions or additions made to existing systems, plans therefor shall be submitted to the State Board for review and approval. Later the law was amended to give the Board special control over emergency intakes and also over industrial connections in manufacturing

plants having a secondary system for process of fire protection. The policy, for some time, has been to eliminate emergency supplies, and the situation now is that resort to emergency sources of inferior quality is a very rare thing. Similarly, we discourage the installation of new cross-connections wherever possible, and an active inspectional program is in effect as regards existing cross-connection installations.

In summary, New Hampshire is fortunate in that it has an ample supply of water resources to meet all of the various types of water-use requirements. With very few exceptions, sources of high natural water quality are readily available, and by means of simple treatment, such as chlorination, these afford the communities served adequate and safe sources of supply. The major problem today, as we find it, is not one of quality but rather involves reinforcement of transmission mains and reinforcement and extension of distribution systems, in order to maintain adequate service under conditions of increased consumption and to serve growth areas within the community.

I think, without question, a great deal of credit for early water-supply progress in New Hampshire is due to the interest and efforts of Prof. Robert Fletcher of the Thayer School, Dartmouth College, who was the engineer member of the Board for many years. Later, Mr. Charles D. Howard, former Director of the Division of Chemistry and Sanitation, and Mr. P. A. Shaw, present member of the State Board, did much to bring about improvement in water-supply systems throughout the State. Finally, of course, mention should be made of the many progressive superintendents who have played an important part in actively promoting water-supply improvements throughout the state.

SEVENTY-FIVE YEARS OF WATER-WORKS PROGRESS IN CONNECTICUT

BY WARREN J. SCOTT*

[*Read September 18, 1957.*]

Connecticut's rapid growth and increase in concentration of population in its many industrial centers has been accompanied by a similar development of public water supplies and of sewage outlets into our streams and tidal waters. It is fortunate that up to the present time all of our public water supplies have been derived from upland streams and ponds unpolluted by sewer outlets, or from unpolluted wells. Another fortunate circumstance is that most of our present natural water supplies are soft.

The time may, unfortunately, have to come when *some* areas may have to take water from large streams, now subject to pollution, for water supply. In the last 25 years especially, considerable progress has been made in installations of municipal sewage-treatment and industrial waste-treatment facilities. Such installations in increasing number will render some of our larger streams of improved quality; yet these streams will always be of decidedly inferior quality to our present sources of supply, and reliance must be placed on filtration and chlorination of the water rather than on treatment of sewage to make such water safe for human consumption. This is not to decry the need for sewage and industrial waste treatment to prevent serious overloading of water-purification plants, but emphasis is laid on the basic difference that will always exist in the two methods of approach toward water safety—the one from clean sources, and the other from sources of inferior quality.

Connecticut's number of chlorinator installations on public water supplies has grown from the first installation in 1913 to 177 installations in 1957. All of our public surface-water supplies and many of our public well supplies are now chlorinated. Filtration installations have made slower progress. Sand filters were installed in Greenwich in 1888 and in Farmington in 1892. The

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number of filtration plants has now increased to 27. Slow sand filters are in operation in Bethel (low service), Farmington, Hartford, New Haven (Lake Whitney), and the Second Taxing District of Norwalk; the remaining installations are of the rapid sand type. It is estimated that 84% of the population of the state is supplied from public water systems. Of this supplied population, 98.5% get chlorinated water, including all those supplied with surface water, and 39.6% receive filtered water also.

It is evident from the treatment statistics that reliance is still placed mainly on clean watersheds and storage to protect most of our supply systems in Connecticut. Chlorination is a much-needed additional protection, but the fact must be faced that chlorinators do break down. Much progress has been made to insure continuity of chlorination without interruption, but there is still not generally the continuous supervision of treatment on supplies provided only with chlorination that is provided, or which certainly should be provided, in filtration plants treating water from inferior sources, nor is there frequently as close laboratory control, with the exception of large water systems. Our water-filtration plants in Connecticut have to date been installed to improve color, odor and taste conditions rather than for safety's sake, even though a tremendous additional factor of protection has been provided by filtration-plant installations.

Cross connections increasingly became responsible for many water-borne outbreaks in the country, and in 1926 the Connecticut State Department of Health, through regulations and their enforcement in cooperation with local officials, launched an intensive program of control, which resulted in elimination of thousands of cross-connections with unapproved water supplies.

Connecticut's record of freedom from water-borne disease in the past few decades has been one of which to be proud. Although the earlier reports of the State Board of Health make frequent reference to the causation of typhoid fever by impure water, in the 1901 report is the first complete account of an extensive water-borne typhoid fever outbreak, which occurred in the city of New Haven. The evidence seemed to point conclusively to infection of the Lake Dawson supply by excreta from a typhoid patient, which were thrown on the ground. The epi-

demic resulted in 105 deaths and probably totalled 1,000 cases. At that time the supply was untreated, and probably no systematic plan of watershed inspection was carried out, as contrasted with present safeguards.

The last Connecticut typhoid epidemic attributed to a contaminated public water supply occurred in 1911, when 35 deaths from typhoid fever in Torrington were apparently traceable to infection of the public water supply by excreta deposited on the watershed. Since that time chlorination and very extensive watershed purchases have been carried out by the water company.

There has gradually grown up in Connecticut a system of sanitary supervision of public water supplies by the state department of health, and it is considered that the results of supervision by state and local authorities have, among other important factors, caused the rapid decline of typhoid fever in Connecticut, where the death rate from typhoid in 1900 was about 30 deaths per 100,000 population, as contrasted with the absence of any deaths from this disease in the years since 1949. For many years we have been fortunate, too, in the absence of other types of intestinal disease outbreaks attributed to water.

The earlier reports of the State Board of Health contain interesting references to the public water supplies of the state. For many years the state exercised only a limited advisory relationship in the matter of public water supplies, the control resting entirely in the hands of local officials. Later on, the advantages of additional control by a state agency, especially in cases of water supply derived in one town and furnished to another, were recognized in granting mandatory authority, at the same time leaving a large measure of control in the hands of local agencies. Increasing statutory authority for sanitary control of public water supplies has been granted by the legislature, and at the present time the state department of health exercises both mandatory and advisory duties in safeguarding public water supplies.

The earliest references to public water supplies in the reports of the State Board of Health are in the 1883 report, where appear brief descriptions of the sources of supply of Torrington, Wallingford and Waterbury, including some chemical and microscopical analyses of the water.

The first record of bacteriological analyses of Connecticut public water supplies by the plating of samples on gelatine and agar along the lines of our present-day methods appears in the 1888 report, when 15 public water supplies were examined. The following annual report refers to the desirability of state control over public water supplies. In 1894, several members of the State Board of Health visited Lawrence, Mass., and the report contains an interesting account and sketches of the sand filtration plant built there to purify the polluted Merrimack River water for drinking purposes. In the 1895 report appears a map showing normal distribution of chlorides in Connecticut waters and, from this time on, increasing numbers of analyses and inspections of public water supplies are referred to in annual reports down to the past year, when nearly every public watershed in the state was inspected by the State Department of Health, and water samples from each supply were examined chemically and bacteriologically at regular intervals of one to three months. Habitations on watersheds are numbered and mapped, and records are kept of sanitary conditions.

The careful system of sanitary control of watersheds has been put to the test by the expansion of populations in rural areas tributary to public water supplies, but by close cooperation of water utilities and the state department of health in following up watershed locations, it can safely be stated that there has been no slipping back in our sanitary conditions on public watersheds. Probably the greatest threat that exists in the immediate future is the continuing pressure of those interested in extending recreational facilities to public water-supply drainage areas.

The state law prohibits bathing in tributaries of public water supplies, and this law is generally adhered to, although there are some difficult situations on very large drainage areas. While there has been some agitation for repeal of the bathing law, the accompanying contamination by urination and fecal matter attached to the bodies of bathers has rather lessened the desire to open up areas for bathing. However, some pressure may continue.

The pressure from the fishermen to open up reservoirs for fishing has been persistent and will continue to be. In Connecticut the state law leaves control of fishing to the local authorities.

On some supplies reservoirs have been opened up for fishing, but the majority have not. In 1955, the legislature appointed a committee to study the recreational use of public watersheds, and the majority report of the committee favored the passage of a state law to open up reservoirs for fishing under some poorly defined safeguards. The writer submitted a minority report. The 1957 legislature did not approve any change in the law but did assign the topic to the state legislative council (an interim legislative research group) for further study. Recreational use of watersheds will continue to be an important consideration to be met in protecting the quality of public water supplies. To plump down on a local community from a state level in easing restrictions is a questionable procedure, because the protection of the supply must largely be local in nature, both as to adequacy and as to cost.

In this discussion there has so far been particular emphasis on water quality. Another essential consideration is water quantity. The quantities of water which are now demanded and will be demanded increasingly in the future have been tremendously stepped up from the early days by the great growth of urban populations, the increased per-capita consumption in the home with the extensions and developments in water-fixture use, use of water for lawn sprinkling and cooling, and the ever-increasing demands by industry. A great tribute is due the many far-sighted engineers and water-works officials who have planned so well in many of our areas to safeguard the populations against the harmful effects of droughts. Two examples of excellent planning in New England are the water supplies of the Boston Metropolitan District and the Hartford Metropolitan District. And yet, Hartford must soon again set its sights beyond the next 25 years or so. Many other examples of good planning could be cited.

It is unfortunately true that in many instances one or more of three deterrents have acted to postpone needed improvements and enlargements of safe yields of water-supply systems. These are: (1) uncertainties of continued industrial demands for water in the future from public water systems, especially in small communities; (2) unwillingness of officials to call for higher water rates on municipal systems, to defray the cost of new projects even though needed, because of political considerations;

and (3) reluctance of privately owned water utilities to undertake new steps without positive assurance that the rates they are allowed to charge will cover the cost.

In Connecticut, a temporary state water-resources commission was set up in 1955 by the legislature, and this commission submitted a report in which it was pointed out that the over-all water resources of the state were adequate, but that serious shortages existed in some areas which must be overcome. The legislature in 1957 combined the state water commission (a water-pollution abatement agency), the state flood control and water policy commission, and the state board of supervision of dams in a new, seven-man, state water resources commission, on which there is one representative each from the recreational interests, industry, power and water utilities, agriculture, municipalities, the public at large, and the state department of health. To date this commission has not been charged with duties in the general field of water-resources planning or control, but this would seem to be inevitable.

It seems to the writer that we have made excellent progress in water-quality control and in keeping pace in most instances with water-supply needs. In the next few decades, however, there must be many strides forward in the whole general field of development of our water resources, to meet the growing demands for water, and this development may bring with it some changes in our traditional and highly successful manner of approach in water-quality control in New England, should it become necessary to make use of inferior-quality water sources, as seems likely. Continued progress in treatment of municipal and industrial wastes will lighten the burden of water treatment. However, the writer staunchly supports the great preference for clean, protected sources of supply whenever and wherever possible. There is no equal substitute.

At present most of our public water supply in Connecticut is from surface sources, but another important resource that exists is the water available in the glacial deposits of sand and gravel and, to a lesser extent, in rock. In Connecticut, the Bridgeport Hydraulic Co. has recently tapped one well supply in a gravel formation that is yielding about 8.5 mgd, and further extensive development at this location is possible. Other utilities

in the state, including many small villages, have obtained substantial quantities of good water from wells. Many areas, of course, do not have such favorable conditions, but as more becomes known of our ground water and our geology, more intelligent planning can be carried forward. Both ground-water diversions and surface-water diversions sometimes open up conflicting competition for water by various interests, such as public water supply, industry, agriculture or recreation. Our riparian doctrine has functioned fairly satisfactorily for many years. It may some day have to be altered, but the administration of other water doctrines has raised many troublesome questions, too.

One of the newest developments in the water-supply field in looking back over the years has been the addition of fluorides to public water supplies, affording a relatively inexpensive method of preventing tooth decay. In Connecticut, fluorides have been added to one state institutional water supply since 1945. In addition, there are now another state institutional water supply, two municipally owned supplies, and one privately owned public water supply where fluorides are added. Other installations are now in progress.

A second new development is in the radiation field. The possibility of harmful effects from radiological fallout and the need for protection in case of war make it highly desirable that water utilities secure equipment and train personnel for radiological testing of water. Background data on radiological content can be obtained in this way, thus affording training in testing and also furnishing useful information for comparative purposes in peace-time as well as in war-time. Some of the Connecticut water utilities have already made provision for this.

In keeping with much water-supply progress in Connecticut in the past 75 years, it is hoped that the years ahead will show extended effective progress in the whole field of water-resources development.

SEVENTY-FIVE YEARS OF WATER-WORKS PROGRESS IN RHODE ISLAND

BY WALTER J. SHEA*

[*Read September 18, 1957.*]

The past 75 years represent very nearly the complete history of municipal water supplies in Rhode Island. The oldest existing supply, that of Providence, went into operation 86 years ago. The Newport and Pawtucket supplies have been in operation 81 and 79 years. All the other municipal water supplies in the state are less than 75 years old.

Previous to the establishment of these municipal supplies, people met their water needs through individual wells or springs; in a few instances from small community well or spring supplies, some dating back 100 years before the establishment of a municipal supply.

The state population 75 years ago was about 280,000, compared to today's population of 827,000. In 1882—75 years ago —the population served by public water supply was 148,000, as compared to today's 761,000. Thus the percentage of people served by public water supply has increased from 53% to 92% in this period. The establishment of additional municipal water supplies followed rapidly after 1882—Bristol and Warren in 1883, Woonsocket in 1884, East Greenwich and Westerly in 1886, Jamestown and Wakefield in 1889, Warwick and Coventry in 1890. Nearly all our present-day major water-supply systems were in operation by 1890.

As might be expected, the municipal water supplies of 1882 were all untreated supplies. They were generally surface-water supplies with only nominal storage. As a whole they would not measure up to today's standards for safety and potability.

The first water supply to install filtration was the East Providence supply. The filter plant of the rapid sand type was constructed in 1899, one of the first of its type in New England. It is interesting to point out in connection with the East Provi-

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dence plant that a study of the means used to wash the filters, reported on in this association's JOURNAL of September, 1941, by Joseph Wuraftic of the Rhode Island Department of Health, involving a low-velocity backwash and rakes for breaking up the sand bed, indicated that this system provided more efficient filter washing than two other filter-washing systems of different types and later adoption.

During the period 1905 to 1910 filtration was adopted by five municipal supplies. Only one of these, the Providence supply, selected slow sand filtration; that was in 1905. The discussion that surrounded the selection of slow sand filters reflects the thinking of that period.

Some of the reasons advanced which led to their selection follow. The efficiency and value of slow sand filters were well established through long experience. They had been selected after thorough investigation by the cities of Philadelphia, Washington and Pittsburgh. The city of Providence wanted the best system; slow sand filters were recommended by a very large number of physicians, and physicians were not in agreement on the advisability of using chemicals. Some said that many citizens would be skeptical of drinking chemically treated water and would continue to buy bottled water. The low maintenance cost was felt to favor slow sand filters; their operation was simple. As approximately 80% of the Providence water supply was consumed by industry, it was feared that the addition of chemicals might produce a water which would not be well suited to some industrial uses. It is surprising to note that the vote of the joint committee of the city council in favor of slow sand filters was unanimous.

Only two municipal supplies in the state are now delivering unfiltered surface water to consumers. One of these is ready to adopt filtration. The other uses unfiltered water, low in color, as one of its several sources.

The first municipality to use liquid chlorine for disinfection was Providence in 1917. Hypochlorite was used by the city of Newport for disinfection as early as 1912. Most of the public water supplies turned to chlorination during the period 1917 to 1921. For many years now all the water supplies of the state derived from surface sources have been chlorinated.

The most far-reaching improvement in the Rhode Island water-supply situation occurred in 1926, when the city of Providence abandoned its polluted, inadequate source on the lower Pawtuxet River for a new impounding reservoir, located on the upper reaches of the North Branch of the same river. The new source provided water in abundance from a clean watershed. This move was of great importance to the state, because the city of Providence serves about half of the state's population.

The State Department of Health has long followed closely the matter of safe public water supply in the state because of the importance it has to public health. As early as 1890 the State Board of Health employed consultants to make analyses of water from public supplies. In 1900 the Board established its own laboratory, and this work has gone on without interruption since.

In 1882 there were 229 deaths from typhoid fever. There has not been a death in the state from that disease since 1947, even though the population is now three times as great as in 1882. It cannot be said that improved water supply is the sole cause of this change, but there is no doubt that it has made a most important contribution. A single outbreak in 1888, caused by polluted drinking water, resulted in 250 cases in Providence.

Progress in preventing this disease as well as others had to await the development of the science of bacteriology. Let me quote from the report of the city Health Officer of Providence for the year 1882. In discussing typhoid fever he said: "I have also known one case in this city where nearly all the inmates of a large house had typhoid fever from the decomposition of a large quantity of potatoes in the cellar". I doubt that this distinguished gentleman would today enjoy being so quoted. I think it is only fair to expect that some of our cherished scientific views of today will sound quite strange 75 years from now, when and if a new group of state sanitary engineers report on another 75 years of progress in water supply.

In review, it appears that management of Rhode Island water-supply systems has been, on the whole, ready to adopt measures that will provide safer and more potable water to consumers, as rapidly as technological advances permit. It is regretted that some of the supplies did not, when it was more feasible, acquire enough marginal area near raw water reservoirs

to provide greater protection against development which carries the threat of pollution to the water source.

The demand for water placed on several Rhode Island water supplies in recent years reached a point where additional sources had to be found. It is notable that in most of these cases resort was made to ground-water development to supplement surface supplies. The relatively small cost and the speed with which such developments can be made make them attractive, even though the amount of additional water obtained is generally small, when compared to that provided by surface sources. The comparatively large-scale recourse to gravel-packed well development and the continued interest in it are interesting new aspects of public water-supply practice in Rhode Island.

These measures constitute little more than short-range solutions to water needs in most cases. It is felt that future needs will require new water-source planning on a broad scale. One of the functions of the new Water Resources Coordinating Board, a permanent agency created by an act of the State Legislature in 1955, is to look into the problem of meeting future water-supply needs in Rhode Island. The board is actively pursuing this objective. In the very near future it will receive from its consulting engineers a report to guide it in the matter.

While it is of interest to review the progress of the past, it is more important to take such steps as will assure an adequate water supply for the future. In the face of the ever-increasing demands for water supply it is hoped that at a later time it can be said that as much wisdom was applied to this problem as to water supply during the past 75 years.

SEVENTY-FIVE YEARS OF WATER-WORKS PROGRESS IN MASSACHUSETTS

BY CLARENCE I. STERLING*

[*Presented Sept. 18, 1957.*]

Mr. Chairman, my distinguished colleagues from the other states have practically said everything I could possibly say.

It is true that in the New England states our state health departments have worked very closely together in the field of water-supply development as well as other fields, and we have taken, or stolen, from each other the best ideas that we saw work in the other states. Thus today we have a fairly uniform policy in regard to the technical aspects of the development of the water, as well as the legal aspects. In Massachusetts, of course, one of the states with the oldest division of sanitary engineering, we have probably done as much basic work during the last 75 years as any other state health department in the country.

I shall give you a few statistics. But 75 years ago—mind you, I know about it only in the last 30 years from personal experience—17% of the population in this state was served with public water supply, and at the same time our typhoid-fever death rate was around 40 per 100,000 persons. By 1920, 88% of the population was served by public water supply, and our typhoid-fever rate was down to two deaths per 100,000 persons. At the present time about 98.6% of our population is residing in towns having public water supply, and our typhoid-fever death rate, as far as water supply is concerned, is nonexistent at the moment, and I hope it continues that way.

We have seen one change in trend in water-supply administration. Originally many of the water-supply systems were developed by utilities, or water companies. Today, particularly in this state, very few of the larger supplies are operated by utilities. They are mostly all municipally owned. We do, however, have a number of small companies. But during the last 75 years 39

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of the larger companies have gone out of business and been taken over by municipalities. The atmosphere for the operation of the public utility company in this state is probably not as favorable as in some of our southern New England states, where a larger proportion are private water companies.

We have seen in this state the usual change in the development of our water systems during the last 75 years. In the beginning everybody was looking for the nearest natural pond where the water would flow by gravity to serve the city, or they went to a spring or even developed a dug well. Today we find that most of the natural ponds that can be used for water supplies are being used for a number of different purposes, and they become more difficult to utilize.

In the last ten years in this state, out of about 234 new sources of water supply developed, only seven were from surface-water supplies, and none of those were from natural ponds. All of the surface sources were artificially constructed reservoirs. Thus our use of natural ponds and taking more and more of our great ponds for water-supply sources have almost come to a standstill, because of the conflicting interests in water usage.

In the development of our ground-water supplies the first ones, of course, were our springs. Later we had filter galleries, where galleries were placed alongside of streams. Still later we had the dug well and then the more advanced tubular well. In this area the driven well, particularly the 2-1/2-inch well, or a group of 2-1/2-inch wells, was a universal source of supply for the smaller communities. Today very few 2-1/2-inch well supplies are being installed; the gravel-packed well has taken over as our new source of water supply.

A complete change has taken place in the 75 years, so that we can no longer go out and say, "Let us have our water natural." We have to look at the fact that our water today is in all cases a manufactured product. We correct it, we try to protect it, in case there is any possible contamination, by the use of chlorine; we correct for the effect of corrosion on piping, and we correct for the amount of hardness or softness in the water. We even correct for the lack of fluorine in the water.

Under our basic law our responsibility in the State Department of Health is to supply not only a pure water but one that

is supposed to be salubrious, and that is the way in which fluorides became a legal possibility for use in this state. Incidentally, we have about 22 communities which are using fluorides in their water at the present time.

The other big improvement I have seen, which has not been mentioned yet, is the fact that we are better able to cope with our emergencies than we used to be. We have had a number of hurricanes and floods throughout the New England area, and there was always great danger of our water supplies' being knocked out of service or polluted water's entering the system. The danger still exists, but we find that with improvements in the pumping equipment, the development of the Diesel engine, and the development of the gasoline engine, most of our stations that have electric power also have auxiliary power to function in case of emergency.

We find that we have a better understanding of how to prevent pollution of our distribution systems, and if we do have breaks in mains, we have procedures of disinfection now which are very effective. In fact, I can't recall in my time that we have had any water-borne outbreak of disease as a result of damage to our water systems because of floods or hurricanes. This indicates a big step forward.

The reason for that, of course, is that we have associations like the New England Water Works Association and the American Water Works Association, which have done such a magnificent job in setting up standards of procedure and doing basic research to help all of us cope with the various problems we are faced with every day.

The last and most important ingredient of the important water-supply operation is the man who operates the system. We find today that, frankly, our water-works superintendent—our operator—is a better-trained man than he was 50 or 75 years ago; he is able to cope with the situation; he knows where to go to get assistance, if he has a particular problem with which he is unfamiliar. Thus today we are in a better position to supply the kind of water that the people demand.

There is one other point I should like to touch upon, and that is the fact that many of our communities no longer can de-

velop a source of water supply within their own areas. I think that day is going very, very fast. We have to look for a broader use of our water resources, possibly developing sources of water supply that can be utilized by a group of communities. At the same time some of the other natural ponds that might be available must be relinquished for other uses, such as recreational uses, and each community should try to develop its own source of water supply in its own community.

Mr. Scott touched upon the development of the Hartford Water District and the Boston Metropolitan Water District, and I can't say enough for the foresighted engineers who developed the Metropolitan supply. When we think of the foresight of those men back in 1895, developing the Metropolitan system as we know it today in the Boston area, it certainly makes one feel very small in his thinking.

I think that in the next 75 years we shall have to be "thinking big" in the proper utilization of our water resources. We in Massachusetts have a new Water Resources Commission feeling its way, the same as in Connecticut, Rhode Island, and the other states. I am sure that the allocation of water is going to be an important function of those commissions in the future.

I hope that we can retain the policy of riparian use of water as long as possible as a general principle. There may be cases, however, in certain limited watershed areas, where we shall have to modify that policy, in order to take care of all the needs in a particular drainage area.

We shall have to be looking at water usage on a much broader basis. I can foresee in the future that the demands for water for recreational purposes are going to pile up upon us, just as our demands for more areas for beaches and other recreational resources are piling up upon all of the states at the present time. When we get a four-day week for working—which may not be too far in the future, according to many economists—we shall have even a greater problem on our hands than we do at the present time.

I was looking back the other day and found that we made a special investigation of the recreational use of our water-supply areas in Massachusetts back in 1919. I reported on something

similar to that, when we made a similar study the past year, and I presented some of the data to the Association this year.*

Our policy has not changed very much. We want to have developed the purest source of water supply for our drinking water and defend it as long as we can without unreasonable demands.

*This JOURNAL, 71:4, 313, Dec., 1957.

SEVENTY-FIVE YEARS OF WATER-WORKS PROGRESS IN VERMONT

BY EDWARD L. TRACY*

[*Read September 18, 1957.*]

The progress of the first 20 years, beginning in 1882, was concerned mostly with the construction of municipal water-supply systems. In some communities, numbers of small water systems intended only for domestic supply were consolidated, enlarged and provided with storage reservoirs. The increased use of iron pipe resulted in the enlargement of supply mains and distribution systems, to provide fire protection as well as domestic supply. Also it was possible to locate supply reservoirs at greater distances from the communities.

Vermont topography made it possible and natural to develop gravity water systems with the sources in mountain springs and brooks. It certainly is true that very few communities in Vermont are very far from a mountain. The water systems built during these early years were the result of individual community effort, with no control and no assistance from any state agency. The consulting engineer and the local officials were entirely responsible for the choice of source and the design of the system. Probably some did not have the benefit of sound advice, as there were a few bad choices of source of supply. It should be noted here that the understanding of water quality before 1900 was quite different from that of the present time.

About 30% of the Vermont public water systems were organized prior to 1890. The first system was established in 1802 in Westminster by the Westminster Aqueduct Co. This system and the operating organization are still functioning with the spring-fed source in the same location. Another 30% of the water systems were built between 1890 and 1900, and the remaining 40% were started after 1900.

The State Board of Health was established by the Legislature in 1886. The Board's active interest in water systems prob-

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ably dates from January 25, 1887, when the members attended the Sanitary Convention in Manchester, N. H., where Professor E. R. Angell of Derry, N. H., gave a paper on "Polluted Drinking Water in New Hampshire". He emphasized that the idea that water can purify itself by running long distances is wrong.

In 1887 the Vermont Board of Health issued Circular 1, titled "Preservation of Public Health". In the section on Typhoid Fever the Board said: ". . . The main source of typhoid fever is the drinking water. When a case of the disease occurs it is the duty of the local authorities to examine the condition of water supplies . . ." It appears obvious that local authorities could only examine the very obvious features of the water system, unless they retained a consulting engineer.

In the biennial report of the State Board of Health for 1896-97, appeared this statement: "Indications of progress are the increased vigilance of health authorities in securing a pure water supply for drinking purposes, which is more than ever regarded as an important factor toward securing good public health . . ."

In the section on Typhoid Fever the Board said: ". . . typhoid fever is a manifestation of sin. Its continual excessive prevalence in any large community, at this enlightened day, places a sin of omission at the door of those who might, by the application of known means, have prevented it . . . Let it be noted that in most instances the cause of the outbreak of typhoid fever can be traced to water. The most serious epidemics are when river water is in use . . ."

Also in the same report: ". . . there have been several outbreaks of typhoid fever in the state which were either directly or indirectly traceable to a polluted water supply—recommendations have been made which have resulted not only in an awakening of interest but a reform in the sanitary conditions . . ."

The most common procedure in Vermont, to accomplish quality improvements during those years, was to develop supply sources in more remote mountain areas, away from habitation. In January, 1897, the Board held a hearing in St. Johnsbury because of the prevalence of typhoid fever there. There were 42 cases of typhoid fever in that town in 1896. Of these cases, 36 originated in the village, and 34 of these used river water.

Sewage discharged into the river above the water-system intake. Many people believed that flowing water purified itself and, oddly enough, many declared that the river water was better tasting than another system, which had its source in a spring and brook-fed pond.

In February, 1898, the Laboratory of Hygiene was organized. In 1899 water analyses of public systems were published, and the water was classified in general groupings. Of 498 samples, 168 were good, 49 were fair, 120 were suspicious and 161 were condemned.

In 1902 the State Legislature passed an Act to prevent the pollution of sources of water supply. This new law gave the State Board of Health supervision over springs, streams, ponds and lakes used as sources of water supply for municipal systems. Representatives of the Board then started visiting communities, to investigate water systems and make recommendations for "remedies for evils found".

The understatement of the report for that year was probably the sentence: "There is much work to be done . . ." The Board proposed the employment of an engineer in 1903 to make thorough examination of various sections of the state where sources of water supply are known to be contaminated by sewage. This recommendation, however, was not actually complied with until 1910, when Josiah Votey, Professor of Sanitary Engineering, University of Vermont, joined the State Department of Health.

During 1902, when the recommendation for a sanitary engineer was made there were 210 positive typhoid-fever findings by the Laboratory of Hygiene. During the years 1900 to 1910 there was an average of 73 deaths per year because of typhoid fever. There also were 30 dysentery deaths, 195 infant diarrhea deaths and 47 diarrhea deaths of individuals over two years of age.

In 1903, Charles P. Moat, Chemist, Laboratory of Hygiene, and a member of the New England Water Works Association, presented a paper at a Health Officers School in Burlington. He emphasized the importance of correlation of field inspections and laboratory analyses. He recommended more frequent sampling. At that time it was not unusual for some cities and

villages to have only one sample per year analyzed. Some communities made the erroneous claim that their water sources were of "undoubted purity".

The Biennial Report of the State Board of Health for 1914-15 was one of progress. The scope of activity had been greatly enlarged. Typhoid fever was substantially reducing, and two epidemics were proved to be due to milk and contaminated food rather than water. The report stated that there were "still a few water supplies that are dangerous". The Sanitary Engineer had surveyed all water systems in the state that were serving ten or more families. The use of chlorine in the form of chloride of lime had started in 1912, and the use of chlorine gas for eliminating contamination began about 1915. The communities that had taken water from rivers receiving sewage, with one exception, had developed new sources of supply and reservoirs. The one remaining river-water system was replaced in 1936 with a new spring-fed reservoir, and since that time no community in Vermont has taken water from a river or stream contaminated by sewage. The only supply source now in use which receives contamination originating from sewage is Lake Champlain, where the dilution factor is enormous.

It should be interesting now to consider what kind of water we have in Vermont public supply systems. Sediment and turbidity are very low, except when mountain brooks are roily following heavy rains. As this condition usually is of short duration, only a very few communities have filtration plants for that reason. Color is good in public systems: never over 20 and in the majority it is between 0 and 5. Odor is never objectionable, except when algae control is neglected. The range of pH is small; 22.1% of the public systems have neutral water with pH at 7.0. Alkaline water constitute 56.7% of the systems, with pH between 7.1 and 7.8, which is the highest value. The remaining 21.2% are acid, with pH between 6.9 and 6.3, the lowest. Only 4% are in the 6.3 to 6.5 group; 6.9% are 6.5 to 6.7, and 10.3% are 6.7 to 6.9.

The typical water is moderately soft In public systems, 43% are under 50 ppm; 18% are 50 to 75; 13% are 75 to 100; 10% are 100 to 125; 10% are 125 to 150, and only 6% are over 150 ppm, with 226 ppm the hardest and 188 the second hardest.

This does not indicate a very extensive market for water softening.

Chlorides are not high; 75% of the public waters are under 5 ppm, and 30 ppm is the highest. Nitrogen is uniformly good, with no nitrites in any public water supply and with nitrates practically all under 1.0 ppm, 4.0 ppm being the highest. There is no appreciable iron, no fluorides (under 0.1 ppm) and no lead in public supply-system waters.

The last 20 years have seen many improvements in water systems. These include reservoir enlargements or new reservoirs, new supply mains, enlargement of distribution systems, new filtration facilities, chlorination and auxiliary wells, mostly of the gravel-packed variety. Communities which have completed major improvement projects during recent years include St. Albans, Winooski, Essex Junction, Burlington, St. Johnsbury, Barre, Rutland, Brattleboro, Springfield, White River Junction (Hartford), Woodstock, Bethel, Proctorsville, Shelburne and Lunenburg.

The list of municipalities which have installed gravel-packed wells is too long to detail here. Although most of these were intended as auxiliary or supplementary supply sources, a few communities prefer the ground water and now use it as the main source of supply.

Chlorination has increased greatly. The number of cities or villages that chlorinate all the water supply continuously has increased 840% since 1940—from 5 communities to 47.

Two municipalities, Burlington and Essex Junction, add fluorides to the water to provide a fluoride content of 1.0 ppm. Two other places, Swanton and Derby Line, are planning to install fluoridation equipment. Several communities have voted on and defeated fluoridation. The increase in fluoridation in Vermont will probably be slow.

The State Department of Health still performs the laboratory service for all the public water systems in the State. Only Burlington has laboratory facilities, and that laboratory is used only for filter-plant control, additional daily samples being analyzed by the State Laboratory. All but some of the smallest water systems sample the water in substantial conformity with the frequency recommended by Public Health Service Drinking Water Standards for bacteriological analyses. Complete chemical

and physical analyses are made once or twice a year by the State Department of Health.

Future improvements will depend greatly on the industrial development. A few communities need additional sources of supply, and some need more water storage for fire protection. Distribution-system enlargements and extensions for fire protection and for housing developments will become more urgent. Perhaps one of the greatest needs will be rate revisions. Many Vermont communities still have "flat rates", or annual charges based on fixtures instead of measure water quantity. Opposition to metering for gravity supply systems, with few exceptions, is quite strong. In most municipalities where growth is likely to occur, the increased water needs have been anticipated and the water systems are ready to keep up with the expansion.

THE GEOHYDROLOGY OF NEW ENGLAND

BY REV. DANIEL LINEHAN, S.J.*

[*Read September 18, 1957.*]

Water is one of man's prime resources and has influenced man in determining his settlements since earliest history. Settlements have been made near rivers, lakes, etc., because of the need of the water supply that would be there. When surface waters could not be obtained, then man began to engineer by diverting streams, digging subterranean canals, or driving wells. We are well acquainted with the knats of the Persians, the bamboo-cased wells of the Chinese and the dug wells and aqueducts of the Romans. Despite the fact that the greater part of the earth's surface is covered with water, still little of this is available to man. The oceans contain over 90% of the world's surface waters, but none of this can be used for most of man's needs. There are more than 6,000,000 square miles of ice in the polar areas, keeping that much water in the solid state so that man cannot use it. The little water that is left to man should be guarded carefully and put to best use.

Some 4,300 billions of gallons of water fall on the United States each day, but the greater part of this, about 3,000 billion gallons, is lost through evaporation or transpiration, and it is from the remaining 1,300 billion gallons that we obtain our present supply. Although the Great Lakes represent our largest surface supply and are equal to 2.5 years of rainfall over the entire nation, or 8 years of run-off, still our subsurface storage is much greater and is equivalent to 10 years of rainfall, or 32 years of run-off.

Water Storage

We cannot depend upon precipitation to take care of our requirements, as it is not constant, or it may be in the form of snow which is not available until the spring thaws. On the other hand, enough rain falls in a year to give each man, woman and

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child over 2,000 gallons a day, but, unfortunately, this is not evenly distributed, and the demands vary whether it be farmland or industrial areas. To collect and store this water is the part of the Water Departments of the various communities. Water must either be stored in surface reservoirs, or it must be stored underground where man must spend his efforts to locate it. Whichever type of storage is to be used will depend upon the finances of a community and the geological setting of the area.

Water Increase and Water Waste

It is well known that water use per capita has increased during the past few generations, and this has been due, in great part, to the introduction of various types of equipment which make for easier living, e.g., washing machines, garbage-disposal units, air-conditioning systems, etc. In Texas, for example, while the population almost tripled from the beginning of the century up to 1940, the demand for water increased 71 times; demand for irrigation waters increased some 55 times, and for power the demand was increased about 85 times. Too, the concentration of the population does not settle where the greater water supply is available, as was true in the past. Other factors, such as climate, commerce facilities, and perhaps even advertising, affect the erection of a community, and some of the necessary natural resources are not always the important factor. We find that even in New England many industries will develop in suburban areas for reasons of the easy commerce afforded by expressways, turnpikes, etc., but give little attention to the availability of water supply for their plant.

We begin to realize the tremendous need Industry has of water. Thousands of gallons of water are required to make one ton of paper, or a ton of steel, and although many of these industries return the water to the source from which they obtained it, it is in a polluted state and cannot be used by others. Water as a coolant and a refrigerant, in some of our eastern cities, accounts for as much as 20% of the daily use. In some areas no regulations exist to control this water after use, and it is wasted although unpolluted. The amount of water discarded by some large installations in this manner could supply a small community with its daily requirements.

The demand for water in the future will be great, as we can readily realize, and communities should plan accordingly, not only for the present increase, but for the greater increase of the years to come, and poor planning on water-supply problems now could cause permanent injury to some communities. Many a Superintendent of a Water Department looks with envy and sorrow upon some real estate development, perched on the most prolific watershed within the communities' limits; or they may discover years too late that the city's cemetery, or dump, or large industrial area rests upon the best water-bearing gravels to be found anywhere. It will be very difficult to advise families that they will have to move elsewhere for the greater good of the community's water supply, or to tell some industry to move to another area in the town. These may move out of the town to another where better planning makes for easier building and lower tax rates.

Geology and Water-Supply Planning

The planning for a water system requires a fairly complete geological survey of the area. The various sciences today are being found to interrelate with one another, and the studies of the present International Geophysical Year are bringing this to the front. The interrelationship between such phenomena as sun spots, solar flares, magnetic storms, induced voltage in power lines, aurora, air conductivity, even the breaking of threads in cotton mills, is well known to the geophysicist. State and community planners should also realize a relationship exists between water supplies and geology.

Hydrology

The science of hydrology may be subdivided into several divisions, and it will be noticed that each of these demands a knowledge of geology to assist it.

Potamology. The study of streams and rivers has to consider both the chemical constitution of the rocks and gravels these waters pass through and over, and it must consider the physical properties of the rocks, their permeability, etc. The run-off and the absorption depends upon the topography of the watershed and the type of soils.

Limnology. The study of surface-confined waters, as lakes and reservoirs, has to consider the same geological features and determine whether leakage or contamination is probable.

Cryology. The study of water in its solid state as ice or snow, requires a good geological knowledge of the shed area to determine how much water will be available after the spring thaws have released this water for use.

Geohydrology. The study of subsurface waters, perhaps requires a greater knowledge of geology and the assistance of a sister science, geophysics, than any of the previous water studies. The difficulties of planning and development of underground water supplies have been due, in the past, to the incomplete geological knowledge of the area. Misdirection, too, due to personal theories on what lay beneath the surface, has resulted in great wastes of the taxpayers' money and of time. There have been as many theories on what constituted good aquifers as there have been water witches with their contraptions to locate supplies.

It is not the part of this paper to give a complete geological course and what is required for determining the amount of underground waters, but a brief explanation may demonstrate that the assistance of a geologist is necessary for any planning for the future.

Igneous Rocks

Within the interior of the earth there is a mass of magma containing all of the chemical elements that make up our surface rocks. This mass will search up through the crust, sometimes slowly and, as a result, crystallize into the granitic type of rocks we observe in various parts of New England. Again, it may intrude or emerge on the surface in rapid flow, resulting in a finer crystal rock such as the basalts or so-called trap rocks. These igneous rocks have many subdivisions, but, in general, we can list them as primary rocks from which many of the other formations may later be derived. In general, such rocks are not good aquifers as they are compact crystalline masses, and unless they have been highly subjected to either earthquakes or fracturing by some other methods, the only possibility of water's passing through them is through minute crevices, and the supply is small.

Some of the igneous rocks, as the basalts which have cooled rapidly, may have numerous joints where water can pass; others, as some volcanic flows, contain small interconnected cavities formed by the expanding gases in the lava, and these can catch, store, and even permit migration of the meteoric waters that penetrate the ground from rainfall.

Sedimentary Rocks

During the process of weathering at the surface, the country rocks may change into gravels, sands or silts. These deposits may then become consolidated into conglomerates, sandstones or shales. The degree of consolidation or the type of cementing material that nature employs will determine whether or not that rock can or cannot be used as an aquifer. In general, most conglomerates present the same properties as the igneous rocks, with the cementing material impervious. Only the system of joints and crevices permits flowage. Sandstones, where consolidation is not too high, make excellent aquifers and, where the shales are thin bedded and fissile, the same qualification may be implied. Given a good aquifer we must then rely on the structure, and how the beds dip, as to whether a certain formation will carry water to a distance.

Other sedimentary rocks that form under water, such as limestones, may also be aquifers, but again, it will depend upon the hardness, the massiveness, and the type of jointing in this rock. Limestones are in some cases easily soluble, and large caverns and channels are created which permit copious flow of underground waters, but without filtration. This type of water is unfit for some uses, due to the amount of calcium in the water.

Metamorphosed Rocks

When igneous or sedimentary rocks are exposed to great pressures and churning due to geological revolutions, the resultant rocks are labelled metamorphics. At times, previously impervious rocks become more pervious and may be utilized as aquifers; however, pervious rocks may be rendered impervious due to this metamorphism. Furthermore, the geological revolution would disturb the general structure and thus prevent gravity flowage of the water to the place where it is desired.

Unconsolidated Sediments

Where rock weathers out into fragments and these, in turn, are deposited either in unassorted or assorted strata the resultant material in its unconsolidated state is of interest to the hydrologist. The porosity of this material will depend upon many items, such as size of the fragments, their shape and the assortment, and these fragments may be of various sizes including cobbles, gravels, sands and silts.

Porosity of a Rock

In considering all of the above types of rocks, igneous, sedimentary, etc., we judge the porosity by the number of cavities, joints and interstices that are found in each rock. Porosity can be defined as the percentage of rock volume not occupied by rock material, and saturation of this rock is accomplished when all of these interstices are filled with water. The permeability of the rock is determined by the capacity of that rock to transmit the water contained under pressure.

Subsurface Waters

Beneath the surface of the ground we usually find a zone of aeration which, with the exception of some water held there by capillary attraction or some perched shelf, contains gases. Below this the ground may be saturated with water that flowed there through gravity. This area must have permeable material to contain the water and also to permit it to be withdrawn under pressure, if the zone is to be used as a water supply. The delineating line between the zone of aeration and the saturated zone is known as the *water table*.

It is possible for this water to be free, in that it flows under hydrostatic pressure until it reaches a point of static level, or it may be confined by some overlying stratum that prevents flow while pressure is being applied to it by the additions of more waters at some distant source. Tapping this confining stratum will, of course, release the pressure, and then the water begins to flow and will rise under the hydrostatic head above the water table or, in this case, the confining stratum. Such a flow is designated "artesian flow" after the locality of Artois, France, where this type of water source was common. Sometimes the term,

artesian, is applied to any sort of a well into rock, but this application is incorrect unless the water will flow above the general water table of the area and shows that it is under pressure. It is also possible to have an impervious stratum in the midst of pervious rocks, and this stratum collects water percolating from above. Drill testing might locate this perched water, giving a false impression that the water table of the area is higher than it is in fact. Such a subsurface supply is soon exhausted if the perched area is small in extent. In the Hawaiian Islands we have many examples of these perched tables, due to the different consistencies of the volcanic ash that makes up the aquifers. These are extrusive and offer excellent supplies. Some areas of New England have small deposits of clay in the gravels, and a perched table here may prove to be small, and water is soon exhausted from such a site.

Although the greater part of the ground water is expected to be derived from the meteoric waters that fall as precipitation and then flow by gravity through the ground, there is the possibility that a stream in the area may leak some of its water and contribute to the zone of saturation. Such a stream is known as "influent". If the stream is receiving water from the zone of saturation, then it is known as an "effluent" stream. If it does neither of these, it is called "insulated".

Care must be taken in extracting ground waters where the locality is close to the ocean. The differences of densities in fresh and salt waters keep them apart, with the fresh water resting on the salt water. However, over-drawing will bring in the salt water, and even too high a velocity of flow will cause mixing. Observation wells should be established between the shore and the source well, to determine any encroachment of the salt waters.

The Aquifers of New England

New England contains few, if any, areas where great amounts of water may be drawn from any of the consolidated rocks. Throughout the Connecticut River Valley we do have sandstones and shales, and even jointed volcanic rocks. These formations dip gently to the eastward, with the formation extending from almost the New Hampshire-Vermont boundary of Massachusetts to Long Island Sound. However, the sandstones

are, in places, too tightly cemented and the shales too massive in their composition to permit sufficient permeability for the waters that might arrive in these rocks from the west. Or, again, there is abundant cross faulting in the strata, which would not permit a sufficient head to be built up, and the waters would be forced out to the surface before reaching any great distance. The sedimentary rocks of the Narragansett Basin are similarly tight, and their structure is less simple than that of the Connecticut River Valley. Over the rest of New England, the rocks are either highly crystalline igneous rocks or metamorphics, or if there are any porous volcanics, they are insufficient in extent to enjoy any capacity for extensive mining of water.

The only rocks left to prospect water from are the unconsolidated sediments. Rock debris that has been transported great distances either by water or ice, and which has been subjected to heavy mechanical abrasion and crushing, and which subsequently has been screened by flow water to carry away the fines will act as an excellent aquifer. Such a deposit should lie well within the water table and, with influent streams nearby to sustain the water table, results in a good producer.

In glaciated regions such as New England, the passage of the ice scours materials from the bedrock as it moves forward and grinds this material in a sort of digestive process, reducing the easily weathered rock to fines and the harder rocks to heavies. Once forward passage of the ice has stopped and ablation takes place, the ice disappears as the melt waters run off, but the carried material, known as till, is dumped with the greater part of it unassorted. Normally the amount of fines in this unassorted till reduces its permeability.

However, other activities have been taking place during the forward progress of the glacier or even near the end of its forward motion and even some activity during postglacial time that render these glacial deposits good aquifers. This reworking of the till results in some phenomena that require individual attention.

Drumlins

Large elliptical hills with their long axes running in the direction of the ice flow are known as drumlins. These are found

in glaciated regions and have suggested to some that they were shaped by the passage of the ice over unconsolidated materials. We are not interested in the origin of these at this moment, but concerning their part in supplying water, we can simply state that they are of no value. The material in a drumlin is too compacted and, at times, cemented to permit suitable permeability. In the past some observers, without a proper knowledge of the general makeup of a drumlin, noticed springs issuing from the base of these hills and thought that water was plentiful within this mass of material. However, the material is so tight and impervious, that water would enter into that zone that had been loosened by frost action, etc., and would follow down the slope of the hill, remaining in the zone without penetrating deeper in the hill and flowing out at the bottom as springs. There is no water table within such a hill.

There have been instances where a drumlin has been deposited on strata of porous gravels. In formations of this sort it is possible to drill through the drumlin and obtain the water supplies beneath. But such instances are rare, and the amount of available water might not be sufficient for community use.

Eskers

Where a river or stream flows upon, within, or under a glacier, there is a washing action taking place on the gravels that make up the bed of this stream, and the fines are removed. Once the ice is entirely melted, this river bed, known as an esker, is deposited in the shape of its sinusoidal course at the site where forward motion of the ice stopped. Those eskers that were formed on top of the ice are of little use to the hydrologist, as their depth below the ground moraine or general till area is small, but those that might be interglacial or subglacial can act as channels to carry waters with excellent permeability and drain the entire area under which they rest.

Kames

Where ablation takes place at the sides of glaciers, and material is dumped along the valley walls, the resultant debris is known as a kame. Kame material is normally unassorted and not too good a producer. It may happen, however, in certain

ablation instances that melt waters do sort the materials and a productive area can be located.

Moraines

Where a glacier comes to rest, the material it has either pushed ahead of it, or deposited in its melting process, is known as a terminal moraine. This same material laid along either side of the glacier would be known as the lateral moraines, and if there is a parallel series of these, marking the junctions of several glaciers into one, they are known as interglacial moraines. Again, this material is unassorted and may not be a good aquifer everywhere. However, it can and does frequently form the material for outwash plains, where the melt ice and even post-glacial erosion will carry away the fines and leave the heavies with greater permeability.

Preglacial River Beds and Basins

The surface topography of a glaciated area does not always depict the preglacial bedrock topography and drainage system. If a preglacial river bed or basin area can be located beneath the till, and there are still sorted gravels and sands in these basins, these can also be an excellent source of water.

Glacial Lakes

During the melting process of a glacier, if the melt waters cannot escape to the sea, then a lake forms with slow-velocity water entering into it. Only the fines are brought in, and these are deposited on the lake bottom as varved clays, which are, of course, useless as aquifers. It is possible, however, that beneath these clays some gravels might exist capable of good permeability.

Unfortunately, the favorable glacial deposits for subsurface water supplies are not spread over New England in such a way that they insure every community that they have adequate water supplies if tested. Many towns find themselves built on exposed bedrock with little or no glacial cover in which to prospect. Some find good streams flowing through their boundaries, but the stream is an insulated one due to the heavy cover of clay, which might be of either marine or glacial origin, but it is too

impervious to be of any use as an aquifer. It is sometimes possible in such a condition to construct gravel beds and charge them with the flowing streams, but this problem is outside of the scope of the present paper.

Use of Geophysics

Following a geological survey of an area, it is sometimes expedient to utilize the various geophysical methods, to probe further beneath the surface before test drilling. The methods in common use are the seismic and the electrical resistivity method.

By using these the depth to bedrock can be ascertained and thus the amount of glacial deposits proven. Drumlin material can be identified; quicksands, clays or wind-blown sands can also be detected by the geophysical methods and these sites discarded before drilling tests are suggested. These methods have been used in scores of communities both in and outside of New England. The geophysical methods do not guarantee sites that will produce copious water deposits, but they do eliminate sites that certainly contain no water.

Various Government and State agencies are at work in New England, making geological and, in some cases, geophysical surveys for future water supplies. Many communities would be wise, however, to plan the same for their own areas as soon as possible. Even though the enlargement of a water system or supply is not planned for the present, potential sites for the future should be chosen and the area purchased by the community, to prevent this land from being rendered unfit for future water development.

ACTUAL TRENDS IN SANITARY ENGINEERING AND WATER SUPPLY IN EUROPE

BY PROFESSOR W. F. J. M. KRUL*

[*Read September 18, 1957.*]

I. INTRODUCTION

Feeling highly honored by the invitation to present a paper at the Diamond Jubilee meeting of the New England Water Works Association, I have chosen a subject of a general scope, which might be of some interest to my American colleagues.

I am aware that the presentation of some results of actual research in the field of water supply would have been more appropriate in view of the high standards of this organization. However, my activities in 35 years of directing a national institute and in many years of international work were evidently mostly devoted to general subjects; they brought me into contact with numerous colleagues in different parts of the world and gave me an opportunity to visit and to compare a number of typical situations and incidental solutions. I therefore hope that the personal character of my birds' eye view of European performances may counterbalance the lack of specialized scientific information.

Being fully aware of the difficulties in international understanding, I feel that first of all I should try to explain what I mean by some terms in the title of my subject: what is meant by "actual"? What by "sanitary engineering"? What by "Europe"?

"Actual" might mean 2,000 years for a man from India and a couple of months for a colleague from Oak Ridge. In my case, "actual" will chiefly mean a period of half a century in general and the years after World War II in particular.

Taking a longer period would be rather hazardous. I am thinking of a treatise on occupational health, written in 1700 by an Italian, Bernardino Ramazzini, the shortened title of which could be translated as: "Historical, Physical and Medical Treat-

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ise on Diseases of Artists, Handworkers and Nuns in Cloisters".

It is one of the first publications on a special aspect of sanitary engineering. In a Dutch translation of 1724, which came accidentally into my hands, I read the following statement on the importance of good care for the health of workers in different professions: "Look at the results in comparing the Europeans on one side with the Americans and other wild peoples on the other".

It seems too bold to try to define the expression "sanitary engineering" in Boston. As a matter of fact, I never would try to give a treatise on the Islam in a mosque at Mecca. For the moment it may suffice that by "sanitary engineering" I mean the whole range of engineering activities to adapt man's environment to actual standards of health and hygiene (1). In England the term "public health engineering" has recently been substituted.

Water supply is one aspect of sanitary engineering and I thought that for a diamond meeting you would agree that I should not limit my subject to technical details of water supply only, but should first try to sketch the general background of environmental sanitation.

As for the term "Europe", it is hard to give a definition.

Let me only say that, abstracting from politics, making Europe too small, and from geography, making our continent too large, we all know about European civilisation and European thought. I am sure that even an Englishman will not hesitate to call himself a European in this respect.

II. Sanitary Engineering

In adopting the above given definition of "sanitary engineering" in its broad sense, we can say that this philosophy has been practised as long as civilisation exists.

Sanitary Engineering in America

The term "sanitary engineering", however, was only explicitly used after "sanitary engineers" had been employed; the cradle of engineers of this type stood in Massachusetts. Gradually in U.S.A. and Canada a sanitary engineering division was attached to every State Board of Health, as well as to the Federal Public Health Service, whereas the military forces em-

ployed such engineers in both World Wars on a large scale. After World War II the American type of sanitary engineer proved to be of invaluable importance for the health programs in backward areas.

This development was only made possible by the integration of sanitary engineering science in the educational programs of a large number of engineering colleges, first of all by the Massachusetts Institute of Technology.

At this moment I want to pay homage to the memory of my regretted colleague and personal friend, Professor Murray P. Horwood, who passed away just a few months before this meeting and who contributed so much to spread the American discipline of sanitary engineering in other parts of the world.

Early Development in Europe

In Europe the history of sanitary engineering tells a quite different tale.

The creation of the American profession was based, in this very Boston, on the belief that biological factors are of prime importance for the influence of the environment upon man, so that sanitary engineering should be based on biological knowledge.

In the life work of William T. Sedgwick, appointed professor of M.I.T. as early as 1881, we find the link with old Europe: his work was based on Pasteur's and Koch's discoveries and mention should be made of the fact that scientific bacteriology perhaps never would have been born without the brilliant work of a very simple Dutchman, Anthony Leeuwenhoek of Delft, in the 17th century.

A parallel of what happened in the eighties in Massachusetts may be seen in the activities in England about 1850, where the consequences of the so-called "industrial revolution" were felt in extremely bad hygienic conditions (2).

A "Report on the Sanitary Conditions of the Labouring Classes" was published in 1842 by Edwin Chadwick, a lawyer, while his famous Bostonian counterpart, Lemuel Shattuck ("Report of a General Plan for the Promotion of Public and Personal Health", 1850), was a bookseller.

Chadwick insisted on the utilization of properly qualified

engineers in the field of sanitation, and the General Board of Health, created in 1848, found a most capable civil engineer in Sir Robert Rawlinson, prepared to set up a technical evaluation of environmental conditions in the country. However, the Board ended its existence in 1854 and since then in England, as well as on the European continent, in all countries public health agencies were gradually installed, but without an engineering staff.

This, of course, does not mean that no technical sanitary measures were taken. On the contrary, there was a remarkable rise of a highly developed technique, especially in drainage, sewerage and water supply, on both sides of the North Sea during the second part of the 19th century. English civil engineers took the lead; they went to the continent as advisers and builders of water works, introducing slow sand filters, as first installed by James Simpson in 1829. Later on the industrial development in Germany led to masterly conceptions of water supply and sewage disposal systems, especially in the Ruhr-region, followed in the 20th century by a rapid development of sewage purification in many European countries; here again England paid an important contribution by the application of the activated sludge principle.

In this respect fairly old institutions in the field of sanitary engineering may be quoted, such as the "Institution of Public Health Engineering" (1895) in the United Kingdom and the "Gesundheitstechnische Gesellschaft" (Sanitary Engineering Society) in Germany.

After the first World War the American idea of sanitary engineering gradually proved to have legs.

On one hand a more or less distorted conception of an engineer, supposed to know very little of a great number of technical and biological branches and serving under a physician, did not attract engineers and hygienists in Europe where public health care had been organized in a vertical sense, with fully independent medical and technical services.

On the other hand, it was felt that the apparent lack of collaboration between the different branches of general health care was no longer in accordance with modern insight in the importance of environmental factors; the conviction gradually

rose that scientific research can only thrive by mutual efforts, based on mutual understanding and adequate education on an academic level.

Undoubtedly the Hygienic Section of the former League of Nations has contributed to some extent to a better understanding of American experience in the field. In my country, for instance, as far back as 1935 a special Section for Sanitary Engineering was founded in the Netherlands Royal Institute of Engineers, in which Section engineers of different branches discuss environmental engineering in close collaboration with medical and biological experts, and which has contributed very much to research and training.

However, only after World War II a real European movement in the field of sanitary engineering was started, thanks to the activities of the Rockefeller Foundation and the World Health Organization.

Influence of the World Health Organization

The aim of WHO can be described as: to obtain the highest possible level of health for all nations, the notion of "health" having been defined in 1948 as an optimal state of mental, physical and social well-being.

Its advisory activities include the rendering of assistance to the affiliated countries in the solution of their health problems in the widest sense of the word, under which "environmental sanitation" has been recognized as very important (3).

It is quite natural that in this respect WHO had to draw to a large extent upon American experience and it is gratifying to state that U.S.A. responded spontaneously and generously.

From the beginning the help of the Rockefeller Foundation was available, which had already fostered dissemination of American knowledge by extending fellowships to European experts and students. Later on American experts acted as temporary advisers and consultants and even more permanently as high officials in the Secretariat of WHO, especially in the Division of Environmental Sanitation. This division started as a "section" under Herbert Bosch, now Professor in Sanitary Engineering in the University of Minnesota, and is actually headed by Professor Herman G. Baity, Sc.D.

In the scope of this lecture I shall have to deal more especially with the WHO Regional Office for Europe.

Very soon after its creation the Regional Office, in cooperation with the European Division of the Rockefeller Foundation and with the Netherlands Government, organized in 1950 a First European Seminar of Sanitary Engineers in The Hague, over which I had the honor to preside.

This Seminar was followed by a second one in Italy (Rome, 1951), a third in England (London, 1952), a fourth in Yugoslavia (Opatija, 1954), a fifth in Finland (Helsinki, 1956), whilst a sixth has been planned for 1958 in France.

It is important to distinguish between these seminars and usual congresses, the seminars being only attended by invited persons, usually two from each country, appointed by the Government at the request of WHO. Participants were mostly engineers with a leading function in the field of environmental sanitation, although always a certain number of medical and other hygienists and biologists were also present.

Each time one or two American specialists and a representative of the Rockefeller Foundation attended the seminars.

The first seminar should, of course, be considered as an experiment. It started with a remarkable general survey ("tour d'horizon"): a delegate of each of the sixteen European countries represented gave an outline of the state of sanitary engineering, the work and training of the engineers in this field and of the methods and the degree of co-operation with medical and other hygienists.

Moreover the program included: drinking water supply (advantages and disadvantages of local versus regional water-works, water extraction in Karst regions, disinfection); sewage treatment and water pollution (small installations for groups of houses and hospitals, self-purifying power of open water, financing of purification plants); research work in the field of sanitary engineering and the possibility of international co-operation; utilization of sanitary engineers in the national care for public health; hygiene of housing; industrial hygiene; swimming pools; domestic garbage; training of sanitary engineers.

The conclusions were of a very general character and stated that this first contact could be considered as being of great im-

portance for the development of sanitary engineering in the different countries, that for nearly all questions touched upon a more intensive and co-ordinated research would be desirable, and that a repetition of such seminars could be an important means thereto. A small advisory committee was created to assist WHO on the application of the adopted conclusions.

The importance and the benefits of this first Seminar might be under-estimated by our American colleagues, living on a continent where a unique historical and political development made it possible to derive a maximum of advantage from modern science and technology. When visiting different States of the Union I was struck by the equality of economic and hygienic level under very different circumstances of climate, natural resources and density of population. In Europe, however, so many historical, nationalistic and linguistic barriers have been built up in the course of centuries that a great variety of economic, social and hygienic conditions is still existing, whereas free interchange of scientific and technical knowledge is still in an embryonic stage.

With this background in view it will be clear that the first seminar opened so many interesting prospects, gave so much insight into what was accomplished abroad in this field and linked so many personal ties, that the advisory committee asked for a prompt reiteration, stating, however, that it would be advisable to avoid in future the—quite understandable—surcharging of the program of the first conference.

This led to more concise agenda for the second seminar, the conclusions of which could be more concrete than those of the first one; they pointed to the importance of a good documentation, for which WHO could be the center, the desirability to confide the task of the difficult problem of international standardization of the quality of drinking water to a small committee of specialists, the importance of an hygienic sewage treatment for houses which cannot be connected to the sewer system (constituting about 70% of the houses in Europe), finally the general desirability of a vocabulary in many languages in the field of sanitary engineering.

The third seminar was limited to one main subject. It was treated so comprehensively that for the first time it appeared

possible to proceed to a printed publication, emanating from WHO (4).

For the organization of the fourth seminar, which was held after a longer lapse of time, more time was available for a thorough preparation. The main subject chosen was the pollution of surface waters. As a preliminary Dr. A. Key, Senior Chemical Inspector of the Ministry of Housing and Local Government, London, made a study tour through Europe, on the basis of which he compiled a general survey of water pollution in Europe. This survey, together with the main papers read at Opatija (health aspects of water pollution with special reference to the epidemiology of water-borne infections; the pollution of surface and ground waters in Switzerland; criteria for the justification of measures for water-pollution control) and an extensive literature on the pollution of water in Europe, was recently published (5).

The second subject of the seminar at Opatija was the chlorination of water; the conclusions were important for an exact appreciation of the different conceptions prevailing with regard to this subject on both sides of the Atlantic. I will return to this subject in my following chapter.

The 5th seminar can be considered as forming a unit with the conference of 1954; again the pollution and disinfection of water were treated, this time, however, with special reference to groundwater, moreover radioactive pollution, the application of other disinfectants than chlorine and sanitary engineering problems, considered in the general scope of the water economy of river basins.

Undoubtedly the WHO Seminars have incited a growing interest in environmental engineering in many European countries, resulting in the creation of special sections for sanitary engineering in existing institutions of civil engineers (Great Britain, Denmark, Finland, Italy, etc.). Moreover they have fostered a close interchange of information between American and European experts.

Education of Sanitary Engineers

With regard to the education and training of sanitary engineers, discussed at the first seminar in 1950, a carefully pre-

pared meeting of professors in sanitary engineering from ten European countries, along with experts of WHO, was held at Oxford during Easter week in 1955. I had the privilege to preside over this symposium. A summary by Prof. M. Petrik (Zagreb), has been printed and can be obtained on application at Geneva (6).

The Oxford Conference, held in the magnificent St. Edmund Hall, one of the oldest colleges at Oxford University, classified the technical control of the living and working environment in five groups: a) drinking water supply and elimination of liquid and solid residuaries, b) housing and town planning, c) industrial hygiene, including air pollution in factories and abroad, d) treatment of foodstuffs and e) struggle against noxious factors of an animal kind ("animal vectors of disease").

Allow me to summarize some of Professor Petrik's conclusions, adopted by the Conference, as follows:

1. It is essential that the sanitary engineer finds his rightful place in the public health administration at various levels.

2. When in Europe the fact will be more generally recognized, that engineers are not sufficiently in close contact with health problems, there will be an immediate and large demand for highly trained sanitary engineers, whereas in under-developed countries throughout the world there is a great and self-evident need for such engineers.

3. In most European countries educational facilities are available for engineering training in special fields of sanitary engineering. The development of education in this field, which is urgently required, must take account of the needs of the less-developed countries.

4. It would be of benefit if instruction in all branches of engineering could include, at an early stage, a short series of lectures dealing with the social, and especially the health, implications of engineering.

5. The preparation of the sanitary engineer should include at least one year of full-time, academic, postgraduate education in this subject.

In this education a number of basic subjects should be included, such as a general review of environmental sanitation, including its role in human society, especially in public health;

epidemiology; chemistry, including toxicology; biology, including microbiology; parasitology and animal vectors of disease.

Meanwhile in some European countries postgraduate courses in sanitary engineering have been organized, as at the Imperial College of Science and Technology of the City and Guilds College (London), King's College (University of Durham), both with the help of the Rockefeller Foundation, the University of Naples, the University of Liège, the "Institut de Technique Sanitaire" under the "Conservatoire National des Arts et Métiers" in Paris and the Federal Technological University of Zürich.

Moreover, at the Technological Universities of Copenhagen, Delft, Stuttgart and Zagreb in the highest semesters of civil engineering a major project in the field of sanitary engineering can be chosen for graduate work, with a background of courses in basic sciences.

Research

Research in sanitary engineering is being performed in a great variety of institutes in Europe, mostly split up in different branches of technique (water, sewage, industrial hygiene, etc.).

In the last decade, thanks also to the incentive of WHO, collaboration is growing steadily between European institutes, some of which will be mentioned in the next chapter.

Since 1945 in The Netherlands a Research Institute for Public Health Engineering has developed as a part of the National Research Council and covering the whole field of sanitary engineering, *viz.* a) hygiene of water, air and soil, b) industrial hygiene, c) building hygiene.

Vocabulary

The compilation of a vocabulary for sanitary engineering in several languages has been undertaken in cooperation with Unesco. The first list, in French and English, will be completed with the help of co-operators in different countries.

Against this general background of environmental engineering I now will try to give some particulars about water supply.

III. Water Supply

In a paper, presented to the New England Water Works Association by E. Sherman Chase in September 1955 on water-works practices in Europe, the author stated that "the headaches of water-works men are the same the world over".*

In admitting this fundamental truth, I still will try to underline some items in European development that are more or less different from American experience.

Legislation and Organization

It is quite natural that uniformity in legal and organizational regulations cannot be expected in such a variety of political, social and economical conditions as are prevailing in European countries.

Water works practice originated in the 18th and 19th centuries in private companies, supplying big cities, and only in the course of the 20th century a need for regulations on a regional and national basis was felt, in which legislation had to play a rôle.

In most countries legislation is restricted to prevention of pollution of ground water or surface water (Belgium, France, Switzerland) whereas in some countries (Denmark, The Netherlands) extraction of ground water is bound to legal prescriptions.

Full size water pollution acts exist in Great Britain (Rivers Prevention of Pollution Act, 1951), giving important powers to the River Boards, and in Belgium (Law against water pollution, 1950). In Switzerland a federal law against water pollution was enacted in 1955, following the adoption of an article on water pollution in the federal constitution in 1953.

The oldest law on water supply as a whole is the English Water Act of 1847, which has been replaced in 1945 by a new Water Act, based on a national water policy.

This example has been followed by The Netherlands, where in 1957 a Water Act was adopted by Parliament, which will enable public authorities to amend the existing organization in the water industry.

Meanwhile only a relatively small number of private water companies have survived in Europe: most of them have been

*This Journal, 70:3, 242, Sept., 1956.

taken over by public authorities and the supply of smaller cities and rural regions is practically exclusively run by local, regional or national public agencies, often in joint boards.

A rare combination is to be found in Paris, where municipal management is restricted to the technical works for production and distribution, whereas the selling of water to the premises is conferred to a private company, the "Compagnie Générale des Eaux" which, by the way, runs a fairly large number of local and regional supplies in France.

An interesting development may be cited in Belgium, where in 1913 a "National Society for Water Supply" (Société Nationale des Distributions d'Eau) was erected by the Government, in the form of a central agency, which creates affiliated regional water companies, run by the interested municipalities with financial aid from the interested provinces and the State and under the central technical management of the National Society.

In the same year 1913 in The Netherlands a Government Institute for Water Supply was installed as a central consulting agency for public authorities and water works undertakings. This institute has proved to be a useful instrument in promoting water supply in rural regions, in raising the general level of water works practice in the country and in contributing to a national water policy. At the actual moment 86% of the total population of 11,000,000 are connected to a piped water supply. A ten-year plan for rural extensions, 4 years of which have elapsed, aims at a percentage of 93. The institute comprises special sections for economics and statistics, juridical affairs and legislation, hydro-geology, chemistry—bacteriology—biology, construction of water works and special subjects (civil defense, individual supplies for civil and military camps, radio-activity, water supply in swimming pools, etc.). The personnel counts about 115, of which some 25 are of academic level.

Other institutes of this kind, although more specialized in research and consulting in biological and chemical aspects of water supply, often combined with sewage treatment and water pollution, are: a) the "Centre Belge d'Etude et de Documentation des Eaux" (Belgian Center for Water Research and Documentation), Liège, closely connected with the University of Liège and supported by industry and the Government; b) the

"Eidgenössische Anstalt für Wasserversorgung, Abwasserreinigung und Gewässerschutz, E.A.W.A.G." (Federal Institute for Water Supply, Sewage Purification and Water Pollution Control), Zürich, belonging to the Federal Technological University; c) the "Water Pollution Research Laboratory", Stevenage, Herts, a part of the British Department of Scientific and Industrial Research; d) the "Rijksinstituut voor Zuivering van Afvalwater" (Government Institute for Sewage Purification), The Hague, Holland.

As interesting examples of research institutes on a private basis should be mentioned: e) the "Association Française pour l'Etude des Eaux" (French Association for Water Research), Paris, set afoot by industrial concerns; f) the "Water Research Association", created by the British Water Works Association, London; g) the "Keuringsinstituut voor Waterleidingartikelen KIWA" (Institute for the Testing of Water Works Materials), The Hague. This institute has the legal form of a limited company; its shares are in the hands of municipal and other owners of water works. It tests all materials and carries on research, promotes collaboration of water works in the field of research and runs the regular chemical and bacteriological water examinations for those water works that do not possess a laboratory.

Whilst most of the above mentioned institutes have good inter-relations, and in most European countries water works and water works men are organized in associations on a national level, international contacts are still far away from the interstate contacts in U.S.A. and Canada.

In this respect the International Water Supply Association should be mentioned, founded in 1947, with its headquarters in London. It held its first international Congress in 1949 in Amsterdam, the second one in 1952 in Paris, the third in 1955 in London and the fourth will take place in Brussels in 1958. By its meetings (the London Congress was attended by 1,500), its Congress Books, its quarterly review "Aqua" and the work of its standing Technical Committee, the I.W.S.A. may prove to be an excellent promoter of international co-operation.

We all hope that many American countries will join this Association in a near future.

Water Resources and Water Economy

The varying geographical and geological conditions all over Europe cause great differences in available water resources.

Where primary rocks, predominantly gneisses and granites, lie at the surface, as in many parts of Scandinavia and Finland (the land of 40,000 lakes), ground water is not available and water has to be taken from shallow natural lakes. Deep tectonic lakes, like in Switzerland and Scotland, offer very good natural resources. In cretaceous rocks, like in England, Austria, Yugoslavia and Italy, ground water may be taken from wells or natural springs. Vienna, Rome and Naples are practically completely supplied, for example, by springs. Glacial deposits, like in the Northern German Plain, may yield considerable quantities of ground water which, however, in many cases has to be freed from iron and manganese and sometimes of ammonia. The whole city of Berlin (3,500,000) is provided with ground water from glacial sands.

Since the 18th century rivers at small distances from the distribution centers were used to supply big cities, like London, Paris, Hamburg, Warsaw, Rotterdam, Antwerp. In the 19th century increasing pollution and increasing water demands have led to the construction of impounding reservoirs in most European countries.

Gradually, as in America, in many industrialized regions of Europe the necessity is felt of a water policy for entire river basins, encompassing a complex of technical and administrative measures and taking into account all interests involved, not only water supply for domestic and industrial use, but also flood control, shipping, power generation, industrial development, agriculture, extension of building sites, fishing and recreation.

A magnificent example of such a policy is to be found in the Ruhr-region in Germany, where three different agencies have been formed by participation of the municipalities, the industry and the landowners, *viz:* a) the "Ruhrtalsperrenverein" (Association for impounding reservoirs in the Ruhr-Valley), which has constructed a system of dams in the Ruhr and its tributaries. This system has to cover the enormous water demands of a densely populated and heavily industrialized region and in the

same time has served the interests of flood control and recreation (swimming and yachting). b) The "Ruhrverband" (Ruhr-Association), which has established a combined policy for water supply and sewage treatment, resulting in the fact that actually the Rhine downstream of the mouth of the Ruhr is cleaner than above this point, whereas formerly the Ruhr was badly polluted; c) the "Emschergenossenschaft" (Emscher-Association), which has converted the small River Emscher, a tributary of the Rhine, north of the Ruhr, into a canal receiving most of the industrial wastes of the Ruhr-region, and has built its world famous treatment works in the Emscher region (Figs. 1 and 2).

On a smaller scale other associations of this kind have been created in Germany, whilst River Boards in England, Drainage Boards in The Netherlands, etc. can also be mentioned in this respect.

Big difficulties are encountered in using water from international rivers. In Europe we are still far away from inter-state regulations, such as have been so happily created in U.S.A. for the Tennessee Valley, the Ohio, the Potomac, etc.

We all know that even in America such regulations were only reached after prolonged studies and negotiations and that the urgency of a national water policy for U.S.A. is recognized by the highest authorities.

In Europe in 1950 an "International Commission for the Protection of the Rhine against Pollution" was set up by Switzerland, France, Luxemburg, Germany and The Netherlands.

This Commission has done very useful work by establishing a system of observation points along the river, from which regularly samples of Rhine water are analyzed by uniform methods in laboratories of the different States.

In this way a good insight in the grade of pollution from different sources has been obtained (7). The Commission has now started to make recommendations to diminish pollution.

Basic points in water economy are control of consumption and control of resources.

Consumption per capita is low in Europe when compared with U.S.A., as may be seen from the following table.

WATER CONSUMPTION PER HEAD AND PER DAY
(approximate figures)

Country	City	Consumption in l/h/d
Belgium	Antwerp	220
	Brussels	160
France	Lyon	400
	Paris	300
The Netherlands	Amsterdam	145
	The Hague	80
Western Germany	Dortmund	380
	Düsseldorf	200
Sweden	Stockholm	280
	Göteborg	210
Switzerland	Geneva	600
	Zürich	280
United Kingdom	London	250
	Sheffield	217
U.S.A.	Chicago	875
	Baltimore	610

The differences are due to many economic, climatic and social factors. The available time does not permit me to enter into details of this interesting subject.

Economical use of water resources can be fostered by storage. A classical example is offered by the Metropolitan Water Board of London, where the unsteady flow of the River Thames and its tributary the River Lee has been counterbalanced by a system of storage reservoirs in the Thames Valley, with a content of 4-6 weeks' consumption. Moreover storage proved to have a very favorable action on the quality of the rather polluted river water, on which point I come back in the next paragraph.

Storage-reservoirs for more or less polluted surface water have since found a large application in the United Kingdom, Ireland and lately at the water works of Antwerp.

Storage can, under appropriate conditions, also be effectuated by infiltration of surface water into the subsoil, a method which may offer great advantages by stabilizing water quality and—especially in arid or semi-arid regions—by preventing evaporation.

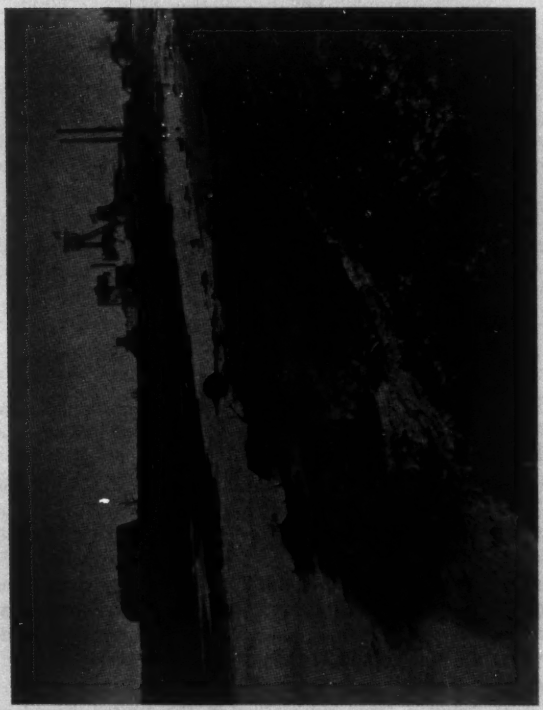

FIG. 1.—STREAM REGULATION IN GERMANY—OLD SITUATION (RIVER EMSCHER).
foto Ramshorn

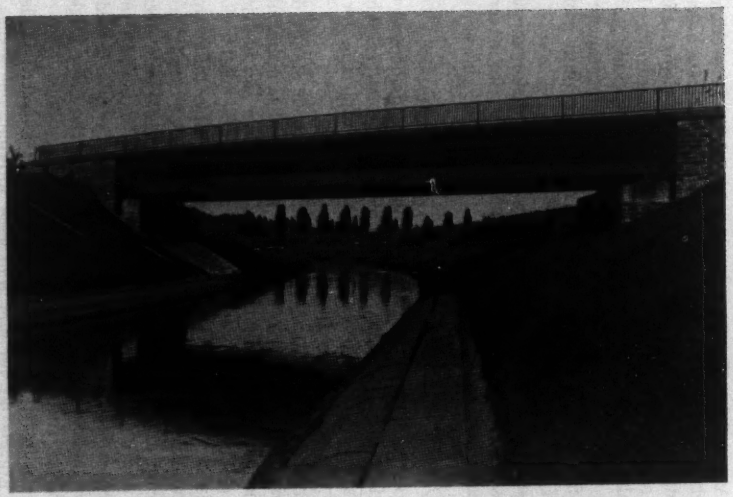

FIG. 2.—STREAM REGULATION IN GERMANY—NEW SITUATION (RIVER EMSCHER).
foto Ramshorn

It is being practised in many places in Europe, especially in Sweden, Germany, The Netherlands and Belgium (8).

An interesting application may be cited in The Netherlands, where Amsterdam, The Hague and other cities were originally supplied with dune water of excellent quality. The fresh ground water in the dunes however showed, in places, a rising salinity, due to overpumping. Recently, polluted Rhine water has been led to the dunes—after prefiltration—(see Figs. 3 and 4) and is being infiltrated in the dune sand. The purifying capacity of the air-filled dune sand converts the river water into groundwater of good quality.

It seems to me that the possibility of subsoil storage should be envisaged wherever the total water economy for a certain region has to be studied (9).

Water Quality

Experts all know that water quality standards depend to a certain degree on the quality of available water resources. Therefore it is very difficult to establish standards, applicable for extremely varying circumstances in large regions.

Standards of quality are meaningless without standardization of methods of water examination and here again difficulties arise from historic development, local chauvinism and individual wisdom or errors in laboratory praxis all over the world.

This explains why and how it was possible to arrive at water standards in a vast continent like U.S.A., thanks to the existence of a federal agency, the United States Public Health Service, and its authority in matters of water supply for interstate carriers; those minimum standards were then accepted by mighty organizations like the American and the New England Water Works Associations.

It explains, too, why no such generally adopted standards exist in Europe up till now and how international bodies, as mentioned above, might play an important role in this field.

As a matter of fact, the International Water Supply Association tackled the problem of water standards at its first congress in Amsterdam, 1949.

Tribute should be paid to the WHO Regional Office for Europe which put the problem on the agenda of the Sanitary

Engineers' Seminars and then created a committee of experts. Its first report, signed 16 March 1956, has been distributed on a small scale (10). It gives recommendations in regard to methods of bacteriological, physical and chemical analyses and standards of water quality, which may be welcome to public health authorities and water works in the various countries. It seems superfluous to underline in this meeting the importance of such standards for the improvement of water supply in backward countries and regions, but also as an incentive for water works practice in higher developed ones.

Meanwhile the Division for Environmental Sanitation of Headquarters of WHO has undertaken an investigation to establish standards for world wide use. A small working group is exploring this task under the leadership of F. W. Gilcrease.

Water Purification

1. Slow Sand Filtration versus Rapid Filtration

The enormous increase of water demand for domestic and industrial purposes inevitably led to the use of impure sources, necessitating physical, chemical and biological treatment.

In this respect a remarkable difference developed in European and American practice, especially in relation with more or less polluted surface waters.

In Europe the application of Simpson's slow sand filter in 1829 marked a new era in water treatment, the enormous importance of which for the elimination of pathogenic germs was only recognized at a much later date.

In America slow sand filtration was introduced not earlier than 1872, at Poughkeepsie, N. Y., and never became very popular, presumably by the heavier load of solids of American rivers and a much higher water consumption.

The construction of rapid filters in the eighties of the 19th century may be seen as the American counterpart of European slow sand filtration.

In Europe rapid filters were applied as a pretreatment phase in the system of biological filtration. In America rapid filtration developed to a principal phase, preceded by coagulation and sedimentation.

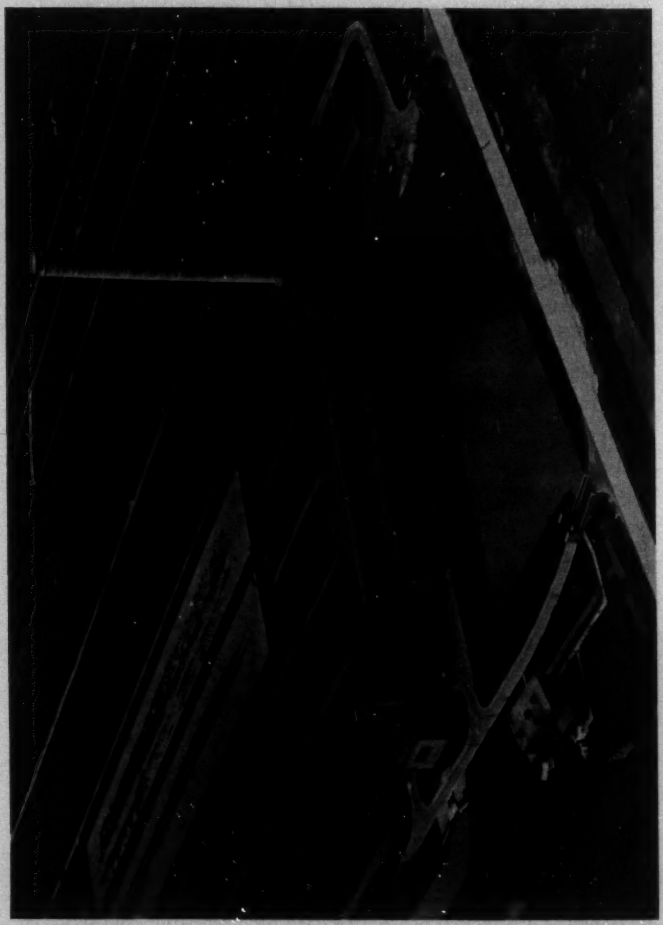

FIG. 3.—PREFILTRATION OF RHINE WATER, TO BE INFILTRATED IN THE DUNES NEAR THE HAGUE. K. A. M.

FIG. 4.—ARTIFICIAL LAKE IN THE DUNES NEAR THE HAGUE. *Gravest*

In the beginning of this century the use of chlorous compounds for water disinfection was introduced at the London Metropolitan Water Board by the famous director of water examination Sir Alexander Houston. He developed systematical post-chlorination of slow sandfilter effluent as a safety factor, which soon proved to be indispensable all over Europe because of the growing pollution of surface waters and the inadequacy of slow sandfilters under special climatic conditions.

Under the leadership of Houston, who was a medical man, and the technical staff of the London water supply—a classic example of collaboration between engineers and medical and biological experts—slow sand filtration, preceded by an adequate pre-treatment and followed by disinfection, was developed to a wonderful complex of a very high standard. Storage of the raw river water causes equalization of quality, sedimentation and devitalization. The result of subsequent pre-filtration of the stored water is a hygienically reliable product, which gets its final touch by slow sand filtration.

Very recently micro-straining has been applied as an economical substitute for pre-filtration.

Needless to say that this very complete system of slow sand filtration is only applicable under special conditions.

2. *Disinfection*

In America chlorination proved to be of a still greater importance than in Europe, as rapid filtration could neither warrant a sufficient bacteriological purification nor a sufficient mineralization of the increasing load of dissolved organic matter.

In this way, chlorination marked the period of practically total disappearance of water-borne diseases in America and perhaps, as seen by European eyes, of an over-worshipping of "the green goddess".

On the other hand, I noticed American feeling towards European practice at an international meeting, where I told for what reasons in The Netherlands chlorination was not applied for the majority of ground water supplies, and the manager of a world-famous American firm answered: "This only proves that Holland still needs a lot of education".

During the European seminar for sanitary engineers in 1954

at Opatija an ample discussion was opened between American and European experts, leading to an interesting common understanding and appreciation of the basic differences in water treatment practice on both sides of the Atlantic.

It was agreed that the quality of water tapped by the consumer depends on three factors: its origin, its treatment and its distribution.

As to disinfection, the conclusions can be summarized as follows (11).

a) When the purity of a source of water supply is not suspect, disinfection is not necessary. When the origin is not naturally pure and safe, purification is necessary, including disinfection as a safety measure.

This European standpoint implies that a bacteriologically pure underground water does not require disinfection.

b) In American practice the principle of maintaining an amount of residual chlorine in the distribution system is widely accepted. It has some admitted advantages, *viz.* that the bactericidal properties of water containing a residual chlorine content eliminate small secondary contaminations; that the magnitude of the residual can give some information as to the degree of contamination; that a residual prevents aftergrowth in the distribution system.

The European standpoint is that a residual does not give security in case of heavier pollution. In such a case the residual simply disappears, whereas in the surroundings the water still contains chlorine, so that bacteriological sampling would only detect contamination when it took place exactly at the point of pollution; therefore it is very unlikely, that the source of infection will be discovered.

Other remarks are the possibility of bad taste and the fact—which never has been proved—that residual chlorine is not dangerous to man.

The European standpoint therefore is, that secondary contamination should be avoided by good engineering (maintenance of sufficient pressure, adequate construction of joints, absence of cross-connections, regular bacteriological control) and that ammonia and organic material, giving rise to aftergrowth, ought to be eliminated by the purification process before distribution.

These principles lead to the conclusion, that residual chlorine should only be maintained in the distribution system when aftergrowth has to be feared and as a safety measure under emergency conditions.

c) The American experience that water-borne diseases, especially typhoid fever and dysentery, have disappeared after the introduction of chlorination does not appeal to the Europeans, as under the European water treatment practice water-borne diseases have equally disappeared.

d) The American system of rapid sand filtration, preceded by coagulation and sedimentation, is finding more and more application in Europe, as biological filtration is becoming very expensive for the increasing quantities of water to be supplied and is moreover no longer adequate for treating different kinds of industrial wastes.

Superchlorination has proved to be a good remedy. In accordance with the European conception, the necessary amount of residual chlorine at the end of the purification system is often taken away by sulphur dioxide or another dechloring agent.

e) In Europe, especially in France, ozonization has been applied on a large scale as a disinfectant, especially for water, poor in organic matter, but unreliable from a bacteriological point of view. Cities like Nice and Toulon in France are provided with ozonised water. In England the famous seaside-resort of Brighton is supplied with ozonized water from the chalk.

Undoubtedly ozone has a greater oxidizing power than chlorine and in many cases is preferable to prevent bad tastes. However, its application is expensive and needs skilled supervision. From the American standpoint it has the disadvantage that it leaves no residual, so that post-chlorination is necessary when the presence of a disinfectant in the distribution system is wanted.

In spite of its disadvantages the general opinion was that the ozonization process is by no means on the wane. In this connection I beg to mention the congress on ozonization, held in Chicago, November, 1956, where a very detailed paper was presented on Europe's biggest ozonization plant in Paris (12) with a nominal capacity of 300,000 m^3/day, put into service in 1953.

Modern ozonization can be seen in Berne, Switzerland (13)

where a groundwater filtration plant with a capacity of 1,000 m^3/h was installed in 1954.

Since almost 30 years the ground water had been chlorinated (without filtration); since 1932 it was chloraminated. However, gradually the dose had to be increased, whereas already very weak chlorine-contents of 0.15 ppm Cl in the distribution system gave rise to complaints of bad taste and odor and of damage to scientific biological experiments.

3. *Deferrization and Demanganization*

As has been said, groundwater in some parts of Europe contains rather heavy amounts of Fe and Mn, which led to the development of various methods of deferrization and demanganization, especially in Germany, Belgium, Sweden and The Netherlands.

In Holland, by the frequent presence of peat in the subsoil, groundwater sometimes contains a large amount of ammonia, together with contents of as high as 10-20 ppm of Fe and 1-3 ppm of Mn.

The Government Institute for Water Supply has developed the application of so-called "dry filters" for such cases, a kind of trickling sand filters, by which a great amount of oxygen is added to the water, resulting in complete oxidation of NH_4, Fe and Mn (14).

4. *Water Softening*

Contrary to American practice central softening of hard water is only rarely applied in Europe, mostly in England.

The prevailing opinion is that softening to a very low degree of hardness should be left to the industrial users of water distributed by public water supplies, whereas the urgency of softening for domestic users has decreased by the rapid growth of the use of soapless detergents in the households (15).

5. *Demineralization of Salt and Brackish Water*

The attractiveness of desalting processes depends strongly on the cost at which fresh water can be furnished by other means. Hence the—up till now—relatively expensive demineralization processes are especially important in arid and semi-arid regions,

prevailing only rarely in Western Europe. Nevertheless in some European countries investigations have been made, especially with a view to overseas territories.

The Organization for European Economic Cooperation (O.E.E.C.) in Paris installed, in 1952, a Working Party No. 8 on desalting of salt and brackish water under the chairmanship of the author, which has coordinated research in several European countries and fostered exchange of experience with the Saline Water Conversion Program of U.S.A.

As a result a three years' technical research program, based on electrodialysis through selective membranes, is now under way at Delft, Holland, under a contract between France, Greece, South Africa, the United Kingdom and The Netherlands, under the leadership of the Central Technical Institute of The Netherlands National Research Board.

At the same time in London research in distillation processes is being performed in cooperation with The Netherlands, whereas in Morocco and Algeria demineralization by ion-exchange is being investigated.

After the constitution of these groups Working Party No. 8 of O.E.E.C. has been dissolved.

Recently, under the Arid Zones Committee of Unesco a central committee for information and coordination has been set up, in which the U.S.A. Saline Water Conversion Program is represented.

6. Fluoridation

Finally a few words should be said on fluoridation of public water supplies for combating dental caries.

In view of the rapidly increasing number of fluoridated water supplies in U.S.A. (and Canada), where more than 700 undertakings, supplying more than 30 million people, apply this new process, it is astonishing that in Europe up till now no definite standpoint has been assumed.

Some experiments on a small scale are—as far as I know—being undertaken in Western Germany (Kassel), Sweden (Norrköping), Denmark (Odense), Belgium (near Namur), Great Britain (Anglesey, Watford, Kilmarnock, Andover) and The Netherlands.

There is a general feeling of hesitation, based on doubt whether the addition of a possibly toxic agent is permissible from the angle of hygienic or medical ethics.

In The Netherlands it is felt that only after successful experiments fluoridation should be permitted and even fostered by the public health authorities.

To this end 4 years ago an experiment was started by the National Research Organization T.N.O. in a city of 16,000 inhabitants (Tiel), where the results of fluoridation of the water supply are constantly carefully investigated by comparing the teeth of school-children in Tiel and in a neighbouring city of equal population without fluoridation. It is hoped that in the course of 1958 it will be possible to draw some provisional conclusions, especially with regard to the optimal dose, which may differ from the American experience, as general food conditions and water drinking habits are not the same in both cases.

IV. Conclusions

In the preceding chapters I have tried to point out some differences in opinions and practice between America and Europe. It is quite comprehensible that, although scientific principles are the same all over the world, there exists a variety of practical interpretation which, however, has a tendency to decrease by the ever-growing possibilities of contact between the most remote parts of the world.

Personally I feel a deep gratitude that a long career in the field of sanitary engineering gave me an opportunity to build up so many personal contacts and I do hope that political circumstances will allow our younger generation to enjoy worldwide collaboration in a measure, which we never dreamt of.

The task, lying before them, is a fascinating one.

In an address, presented in 1949 to the Federation of Sewage Works Associations, Professor Fair gave an outlook on the challenge of the future to sanitary engineering (16) and in this respect I beg to quote Abel Wolman, who said: "A water works man of to-day has still a world to conquer".

Indeed, a century of technical development has found means to eradicate many scourges of mankind by remodeling environmental factors. However, biological science has taught us that

life's flexibility is enormous and that—as Beyerinck, professor in biology at our Delft Technological University, has expressed it—(in micro-biology) "everything is everywhere". This means that under special ecological conditions every development of organisms is possible, so that environmental conditions are changing constantly. Engineering methods will have to change with them!

In water supply we have found methods to prevent some water-borne diseases, but every day new possibilities of contamination are being discovered, for which traditional methods of detection and evaluation are insufficient. Moreover, in many parts of the world the growing water demands are menacing the development of civilization, as they did in semi-arid regions millennia ago.

Last but not least, on a certain level of civilization the activities of a wide range of scientists and technicians should be devoted to restoring and assuring such essentials of good health to ever growing populations as cleanliness of lakes, streams and rivers and palatability of distributed drinking water, exempt from bad odors and tastes.

After all, there is an amount of wisdom in a sentence, written by an English boy at the occasion of a school competition: "Hygiene is keeping clean when it is not essential".

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DEVELOPMENTS IN EQUIPMENT FOR WATER WORKS IN NEW ENGLAND

BY R. S. RANKIN*

[*Read September 16, 1957.*]

This review of developments in water-works equipment during the past 75 years in New England is being limited to a few subjects selected arbitrarily, but which have been important factors in the water-works field. To make this subject more than a recitation of facts and events, which could prove dull and uninteresting, a series of pictures is being used to illustrate the developments. One picture is said to be the equivalent of many words, and it is hoped this will prove true in this presentation.

To limit this discussion to equipment development solely in New England seems impractical. Many worthwhile ideas which originated in New England were promptly adopted outside and continued to be developed and improved. Likewise, ideas originating beyond the boundaries of New England did not halt at the borders, but were accepted and given similar treatment. It is quite evident from a review of the technical journals and press of former days that a free exchange of ideas prevailed between New England and the rest of the country. Consequently, the subjects or items which have been selected for illustrating the development of equipment had their initial beginnings or received an important contribution to their development in New England. Wherever they originated, they have been important factors in the history of New England water works.

The subjects selected for pictorial review include:

1. The Venturi Meter
2. Household Water Meters
3. Pumping Machinery
4. Liquid Chlorine Equipment
5. Water Filtration
6. Mixing and Flocculating Equipment

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Editor's Note: This paper is an abbreviation of the paper read by the author on Sept. 16, 1957. Due to limitations of space, it has been necessary to omit some 50 illustrations.

Suitable materials for use in this review are more readily available from manufacturers who have participated in these developments than from other sources. Therefore, to make an intelligent story, the cooperation of several such concerns was solicited, and their response has been very generous. Those who had a continuous background from the time of introduction or advent of new equipment to the present were deemed most useful for this purpose. This is not to be construed by implication that numerous other concerns have not participated in other important developments; it means simply that having adopted this method of obtaining information, the selection of those able and willing to supply it had to be arbitrary.

It is realized that it is not customary to identify manufacturers by name in any technical discussion. However, in this presentation, it is scarcely avoidable, and indeed their contribution justifies acknowledgment in some form. Those manufacturers who are named, however, are sufficiently well known in their respective fields so that any publicity is certainly not going to enhance their established status.

One might question whether a transplanted midwesterner is qualified to attempt to treat this subject in a manner acceptable to the water-works men of New England. The answer to such a question, for what it is worth, is that his introduction to the water-works field was made in the summer vacation of 1911, when he obtained a job as junior timekeeper and instrument man on the construction of the 39-mgd filtration plant for the city of Minneapolis. This was one of the early, large, rapid sand filter plants designed by Hering and Fuller. Construction by day labor caused it to drag through three more summers and then, when finally placed in operation in 1914, a one-third enlargement was ordered, designed on the ground and constructed during the next year. This initiation resulted in a decision to continue in this field of sanitary engineering, which has been followed ever since with only minor variation.

Here in the city of Boston, the story of the development of an adequate water supply could fill volumes and, in fact probably has, but one of the most interesting chapters was the very first. It seems fitting to make brief mention of this eventful step when in 1848 water from Long Pond, renamed Lake Co-

chituate, was brought into the city (Fig. 1). Some twenty years of debate preceded this event and involved such families as the Quincys, the Eliots, the Hales, and many others. Public mass meetings at Faneuil Hall were frequent, and the arguments pro and con appeared in prose and verse. The achievement was climaxed by the discharge of 100 guns, a parade, and a gather-

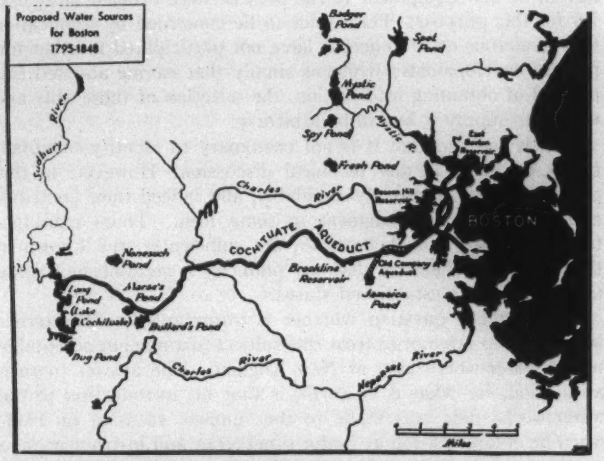

FIG. 1.—PROPOSED BOSTON WATER SOURCES, 1795-1848.

ing of 50,000 to 100,000 persons on the Boston Common to witness the water rising from the fountains (1).

Thus Boston became one of the first New England cities to have a public water supply. Although the initial works has been repeatedly enlarged and expanded, it is doubtful that such public acclamation was ever repeated.

Another interesting "first" in Boston that deserves mention was the opening in 1889 of the first biological laboratory on an American water-works system at the Chestnut Hill Reservoir, under the direction of Desmond Fitzgerald. Studies at this laboratory first established the correlation between micro-organisms and tastes and odors in water supplies (2).

Water-Works Systems in New England

Water-works systems in New England in 1880 numbered 137 (Table 1). In 1888, six years after the birth of the New England Water Works Association, there were 286 systems with a total investment of about $85,000,000. Massachusetts led with over 46% of the total number and 66% of the total investment. Unfortunately, there are no readily available current data on this subject for comparison.

TABLE 1.—WATER-WORKS SYSTEMS IN NEW ENGLAND IN 1888

	No.	Investment (millions of dollars)
Maine	42	6.4
New Hampshire	30	2.9
Vermont	22	1.4
Massachusetts	133	56.0
Rhode Island	16	9.4
Connecticut	43	8.8
Total	286*	84.9

* In 1880, 137 systems.

REF.: Manual of Am. Water Works, 1888, by Eng. News.

The Venturi Meter

One of the major developments in the water-works field anywhere was the New England invention in 1887 of the Venturi Meter by the eminent hydraulic engineer, Clemens Herschel. Herschel, born in Boston in 1842, was employed by the Holyoke Water Power Co., which supplied water to mill turbines in that area. It was also equipped with an outstanding laboratory for testing water wheels. Prior to Herschel's invention, measurement of flowing water was made largely by weirs, but this method was not directly applicable to pipe flows. Herschel conceived the idea of "placing an orifice at some point in the pipe circular and in the form of an adjutage, and then placing an expanding cone downstream from the orifice, in order that the loss of head occasioned by the first orifice may be regained and no material loss of head be occasioned by the whole apparatus".

Herschel tested his idea with a one-foot and a nine-foot meter, using the facilities of the Holyoke laboratory, and presented his results in a paper before the A.S.C.E., December, 1887. He christened it the "Venturi Meter" in honor of the 18th century Italian physicist—a generous act. Herschel then developed the familiar formula from his tests (3).

Having developed the meter tube, Herschel realized it was still not a practical tool without a registering device. This led

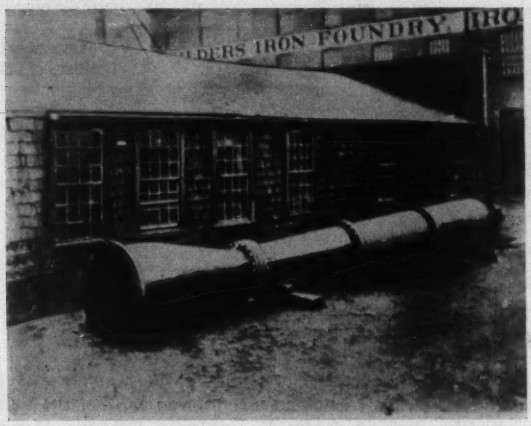

FIG. 2.—FIRST VENTURI TUBE INSTALLED IN 1891.

him to the Builders Iron Foundry in Providence, where the first commercial tube was fabricated, and the first automatic totalizing register was developed. The latter was a contribution of Frederic Connet, their chief engineer. Herschel's association with the engineers of B.I.F. lasted 40 years until the death of the former in 1930.

The first commercial Venturi Meter was installed in 1891 for the East Jersey Water Co., shown in Fig. 2. The first New England installation followed shortly thereafter at Worcester, Mass. The Venturi Meter soon became world-wide in its applica-

tion. Figures 3 and 4 show current designs of the long and short tubes.

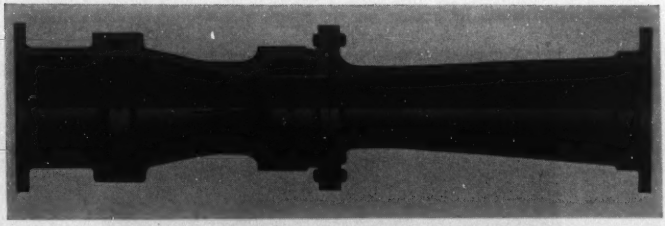

FIG. 3.—PRESENT STANDARD LONG VENTURI TUBE (BUILDERS—PROVIDENCE).

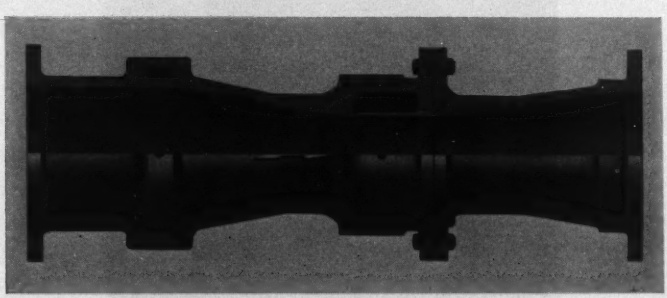

FIG. 4.—PRESENT STANDARD SHORT VENTURI TUBE (BUILDERS—PROVIDENCE).

Household Water Meters

While on the subject of metering water, at the other extremity from the standpoint of ability to measure volume is the rotary disc meter used on house or domestic services. Numerically, this type of meter probably exceeds all others combined in water-works service, and it represents a very important segment of any system.

The invention of the disc meter in its basic form dates from 1887-8, and apparently it was an immediate success and its use spread rapidly. The cast-iron frost bottom was added in 1896. In the early 1920's, oil-enclosed intermediate gear trains were

developed. Prior to that time open-wash water-lubricated gear trains were used on all meters. This improvement overcame a great deal of difficulty with open-type gear trains under corrosive water conditions (4).

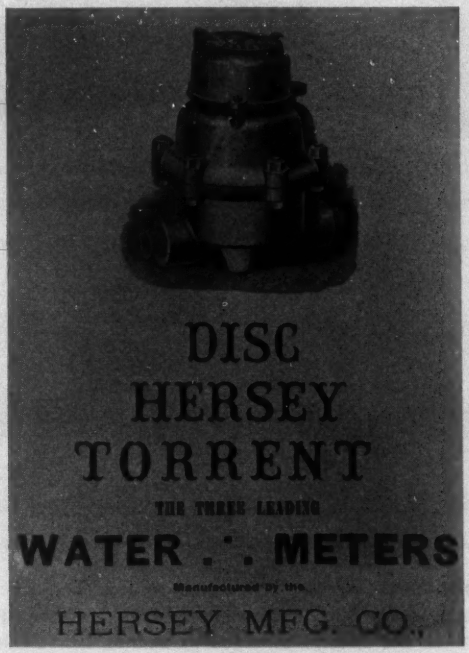

FIG. 5.—HERSEY ROTARY DISC METER, 1899.

The first major effort in standardization of water meters culminated in 1921, after many years of joint efforts of committees from New England Water Works Assn., American Water Works Assn., and manufacturers. This work was reviewed in 1930 and the present standard adopted in 1940 (5).

The only manufacturer in New England now making water

meters is Hersey Manufacturing Co., which began making them in 1885 largely through the influence of their James A. Tilden, who for many years was an associate member of this association. Apparently the outward shape of the rotary disc meter was re-

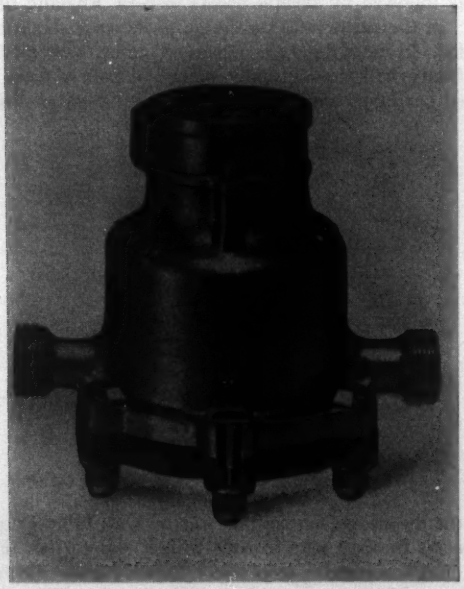

FIG. 6.—HERSEY ROTARY DISC METER, 1957.

solved early, as shown in Fig. 5 which illustrates a meter in 1899. A view of a meter in 1957 is shown in Fig. 6.

Water-Works Pumping Equipment

A major item in almost every water works is its pumping equipment, despite every effort to have gravity do the job. One of the early manufacturers who designed and built pumps was Henry P. Worthington, whose name still survives in the Worth-

ington Corp. He made his first pump in 1840, and by 1876 there were 80 installations in the United States and Canada. By 1892 this had increased to 1,160 pumping installations (6).

The first duplex pump for water works was built in 1863 for Charlestown, Mass., with a capacity of 6.0 mgd (Fig. 7). This was followed by several others in New England of similar pattern. In the early 1890's a device to increase steam economy was added. In those days efficiencies of pumps were measured in terms of duty, which was usually defined as ft-lb of work per 100 lb of coal per hour, and this was a frequent topic of discussion.

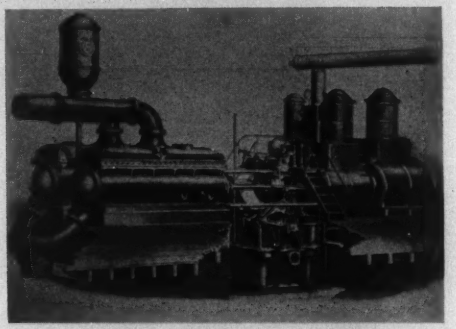

FIG. 7.—WORTHINGTON DUPLEX PUMP, CHARLESTOWN, MASS., 1863.

In the meantime competition was at work in other quarters, and it seems the best way to cope with it was to join them. As a result four companies from 1899 to 1902 were absorbed by Worthington. Today it would be called a merger. These included Blake & Knowles Steam Pump Co. of Cambridge, Mass., the Deane Steam Pump Co. of Ludlow, Mass., the Holly Manufacturing Co., and Snow Steam Pump Works from New York State. All had been familiar names among water-works men.

The culminating effort in steam-driven pumps for water works was exemplified by the huge triple-expansion unit, which was truly a marvel of mechanical engineering and a wondrous sight to behold. Figure 8 is a scale outline of a 40-mgd unit compared to a man. Many a meeting of the Association in these

early days was devoted to a discussion of the fine points of these steam-driven pumping engines (7).

Like the recent demise of the steam locomotive, however, reciprocating pumps began to give way in the early 1900's to the

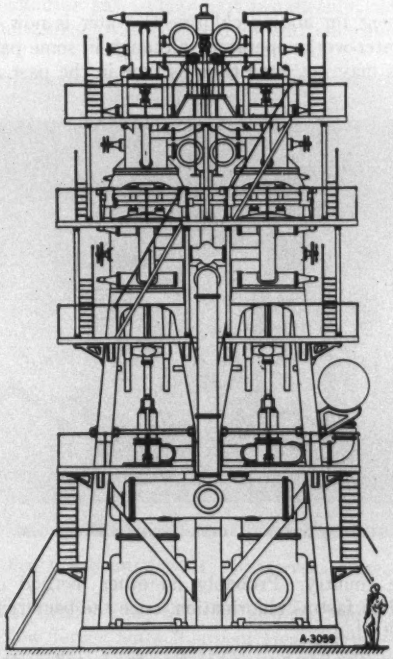

FIG. 8.—40-MGD TRIPLE-EXPANSION PUMP, 1904.

centrifugal pump. Figure 9 is an early design of such a steam-driven unit. When high-speed alternating-current motors became available, they proved to be the ideal prime mover for the centrifugal pump and, because of economy of first cost, simplicity, and the great reduction in space requirements, they gradually displaced the ponderous old steam pumps.

A current design of centrifugal pump is shown in Fig. 10. Refinements in centrifugal pump design since their introduction have resulted in ever increasing efficiencies.

Chlorinating Equipment

Equipment for adding chlorine to water is now familiar to almost all water-works operators, although in some parts of New England this may not have been as true in the past as in other

FIG. 9.—WORTHINGTON STEAM ENGINE-DRIVEN CENTRIFUGAL PUMP, 1904.

parts of the country. Probably no other method of treating water spread so fast as chlorination, once the bactericidal effects were demonstrated.

Credit for the first use of chlorine gas to reduce the bacterial content in the effluent of a water filter should be given to William F. Jewell of the family whose names are interwoven with early water-filtration developments. During the Louisville Filter Testing Station operation in 1896, Jewell installed a device on the effluent of his test filter which operated for about 10 days, applying chlorine at the rate of 0.25 ppm. He was then ordered to discontinue it because it was said to be unfair to Jewell's com-

petitors (8). Jewell was simply too far ahead of the times—in fact, just 16 years ahead.

In 1912, Wallace, an electrical engineer, and Tiernan, a chemist, teamed up and decided to design and market equipment for feeding chlorine gas. Their first installation, sold for $150 including guarantees, was designed to add chlorine gas in the

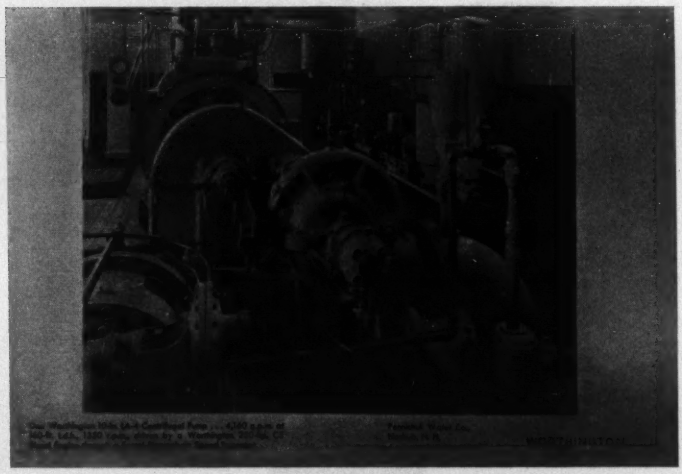

FIG. 10.—NASHUA, N. H., CENTRIFUGAL PUMP.

bed of a small stream used as drinking-water supply for Jersey City. The New Jersey State Board of Health representative approved the installation when he detected the odor of chlorine coming from the water in a favorable breeze, saying: "That smells okay" (9).

The next similar installation was sold for $200. In 1913 the Stamford (Conn.) Water Co. was in the market for sterilization equipment, but wanted it to feed the sterilizing agent in proportion to the flow. Wallace and Tiernan offered to build an automatic chlorinator for $500 and guarantee it for two years.

They went back to their headquarters and designed the first automatic chlorinator. Similar installations were made that same year at New Haven, Torrington, and Hartford, Conn. (9).

Apparently the Massachusetts Department of Health did not take to this "new-fangled" idea, for in 1916 H. W. Clark, Chief Chemist, said that only one water supply in the State used

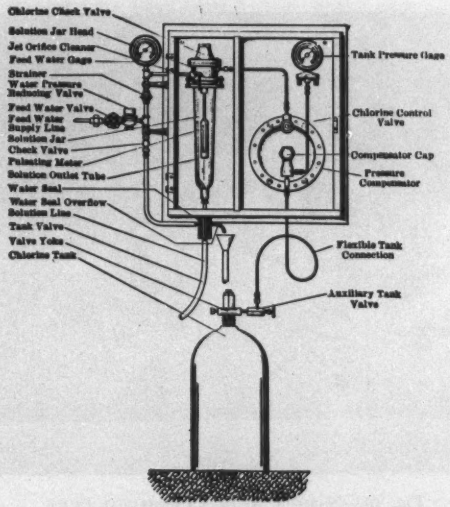

FIG. 11.—MANUAL-CONTROL CHLORINATOR, SOLUTION-FEED, TYPE A.

disinfection (Wakefield) (10). They have little use for it, relying on storage (11).

The early installations fed chlorine gas directly to the water undergoing sterilization, but this proved difficult to control and regulate. Very soon the equipment was changed to feed the gas in solution, a practice continued to the present.

Figure 11 illustrates an early manual type of chlorinator, and Fig. 12, an early automatic unit. Figure 13 is a typical, modern high-capacity installation in a water plant.

The merits of chlorinating a water supply have long since passed the debating stage. Now developments are mainly centered on refinements of technique and equipment.

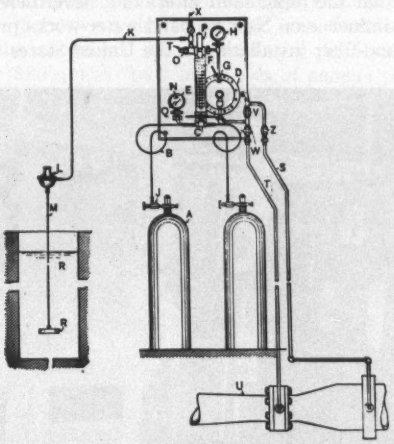

FIG. 12.—AUTOMATIC CHLORINATOR, DIRECT-FEED TYPE (WALLACE & TIERNAN).

Water-Filtration Equipment

In the broad field of filtration only a few significant milestones can be discussed. Table 2 gives the extent of this development in New England in the 40 years from 1900 to 1940. The current total must be well over 100 plants. In 1940 Massachusetts had over half (17) the slow sand-filter installations,

TABLE 2.—NUMBER OF WATER-FILTRATION PLANTS IN NEW ENGLAND

Year	Slow sand-filter plants	Rapid sand-filter plants	Total
1900[a]	5	16	21
1940[b]	35	58	91

[a] Allen Hazen, "Filtration of Public Water Supplies", 2nd Ed., 1900.
[b] Public Health Reports, Vol. 57, 1942, No. 45, p. 1679.

and Connecticut over one-third (20) of the rapid sand-filter installations in New England.

Although slow sand filters did not offer the opportunities for equipment that the rapid sand filters did, nevertheless they had a profound influence on New England water-works practice. The first slow sand-filter installation in the United States was in 1872

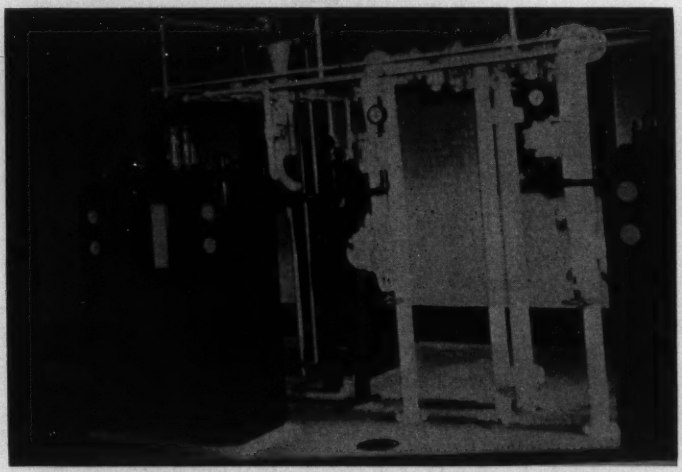

FIG. 13.—TYPICAL, MODERN, HIGH-CAPACITY CHLORINATOR INSTALLATION.

at Poughkeepsie, N. Y., the second at Hudson, N. Y., and the third at St. Johnsbury, Vt. (12).

The Massachusetts Department of Health took an early interest in slow sand filters and developed many basic data at its Lawrence Experiment Station. In 1892, following a severe typhoid epidemic in the city of Lawrence, the State Department of Health advised the city to filter the water and offered to show them how to do it (13). The city followed this advice and engaged Hiram F. Mills, who in 1893 constructed the first slow sand-filter installation having as its objective the reduction of typhoid fever. Six years prior to the installation, the annual

typhoid death rate averaged 120 per 100,000 population; six years after, the rate was 26, a reduction of 78% (14). It is no wonder that slow sand filters made progress in Massachusetts.

Rapid sand filters, or mechanical filters as they were called in the early days, were the equipment manufacturer's dream. Impetus to the mechanical filter started with the Hyatt brothers in the early 1880's, who "took out scores of patents on filtration procedure and apparatus", including simultaneous coagulation-filtration. By 1888 Hyatt claimed installations in some 30 cities, including Newport, R. I., and Greenwich, Conn.

Meanwhile at the paper mills of S. D. Warren & Co., Cumberland Mills, Maine, one John E. Warren in 1884 designed and constructed what was the largest mechanical plant in existence with a rated capacity of 12 mgd. Subsequent Warren plants were constructed at Augusta and Brunswick, Maine, in 1887.

Some important data on rapid sand filters were obtained from a series of tests lasting 10 months in 1893-4 by Edmund B. Weston of Providence, on the Pawtuxet River. The experimental filter, 30 in. in diameter, washed by reverse current and revolving rakes, and using 0.7 grains per gal, was operated at 128 mgd and removed 70-90% of the color and 95% of the bacteria (15).

Numerous companies entered the field during the 1890's with patented devices, and there was constant litigation. However, the three Jewell brothers (who came from the midwest) entered the field in 1888-1890 and ultimately survived this hectic period of mergers in the company formed and called the New York Continental Jewell Filtration Co. In 1906 this company claimed 220 plants, and 360 in 1909. Another company which entered the field and still survives is the Roberts Filter Manufacturing Co.

A typical filter unit of the 1900-1910 era is shown in Fig. 14.

Meanwhile, in 1895-1897, a revolution in the concepts of water filtration was in progress at Louisville, Ky., under the able direction of George W. Fuller and associates, who previously had been doing outstanding work at the Lawrence Experiment Station. The staff at Louisville was remarkable in the number who achieved top recognition in their field. Fuller's work showed that coagulation and sedimentation ahead of filtration were of para-

mount importance, particularly in the treatment of turbid waters. This was contrary to all current practice.

In 1902, the first plant to be designed on the basis of the results at Louisville went into operation at Little Falls, N. J. This plant has had an effect on every gravity rapid sand-filter plant built since that time. The filters were rectangular instead of round, of concrete rather than wood or iron. Coagulant was added at the entrance of a detention basin instead of just ahead

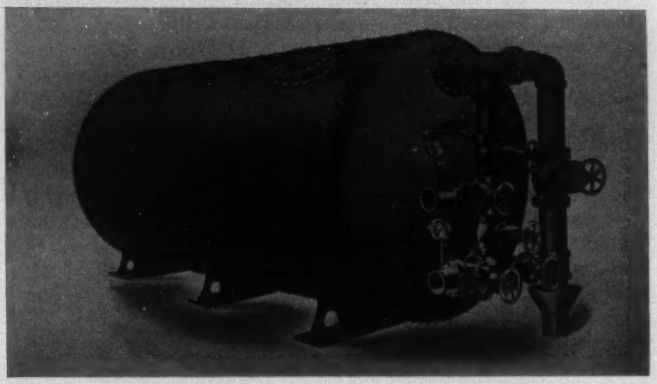

FIG. 14.—ROBERTS HORIZONTAL STEEL-TANK FILTER.

of the filters, and compressed air and water were used for backwashing rather than revolving rakes and water.

A typical filter plant of 1910 is illustrated in Fig. 15 (16). The new York Continental Jewell did a thriving business for a few years with their patented devices, but it was quite obvious that the equipment market was now wide open to competition.

One distinct contribution of New England to modern water filtration practice was the Wheeler Filter Bottom. William Wheeler, a Boston consulting engineer, in 1907 made the first design for a plant in Kentucky, which for some reason was never built. In 1913, however, Wheeler and Robert Spurr Weston worked out a design for a plant in Belfast, Maine, which went into operation in 1914. Before completion of the final design,

tests were conducted by them at Concord, Mass. The first test included 30 3-in. spheres, but this proved unnecessarily refined and the adopted design included 14 spheres, 5 of 3-in. dia., 8 of 1¼-in. dia., and 1 of 1½-in. dia., nested in an inverted pyramid (Fig. 16) (17). In 1915 Wheeler bottoms were designed into the

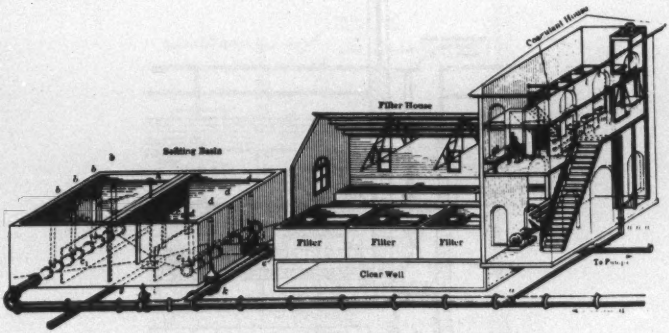

FIG. 15.—TYPICAL FILTER PLANT, 1910-15.

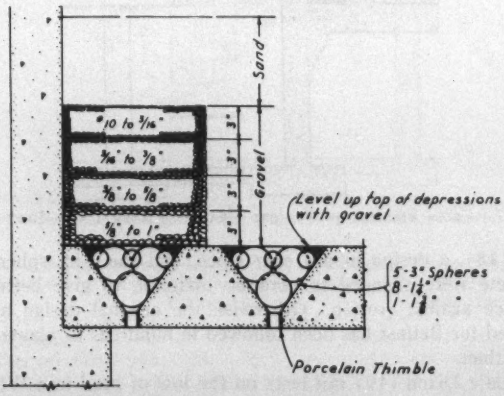

FIG. 16.—ADOPTED DESIGN OF WHEELER FILTER BOTTOM.

Akron, Ohio, 20-mgd plant by Frank A. Barbour, and in 1916 into the extensions to the Little Falls, N. J., plant. These early installations included tapered concrete laterals, and the 3-in. spheres were of concrete. In 1917 additions to the Akron plant included a false bottom to provide better wash-water distribu-

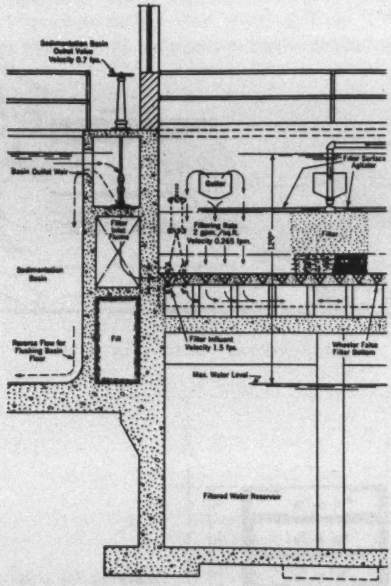

FIG. 17.—CROSS SECTION OF TYPICAL GRAVITY FILTER UNIT—LEFT HALF.

tion (18), a design in use ever since, and the 3-in. spheres of concrete were changed to ceramic material, to give better resistance against erosion. Otherwise the original design as developed for Belfast has been followed in hundreds of plants built since then.

Gale Dixon (19) ran tests on the loss of head in a Wheeler type of bottom compared to the conventional pipe-lateral type, with results showing the Wheeler bottom had less than 55% of

the loss of the perforated-pipe type at rates of wash normally used (Table 3). He also stated the Wheeler bottom was less costly, based on actual bid. Figures 17 and 18 show in cross section a typical gravity-filter unit.

Filter plants may be attractive and a real architectural con-

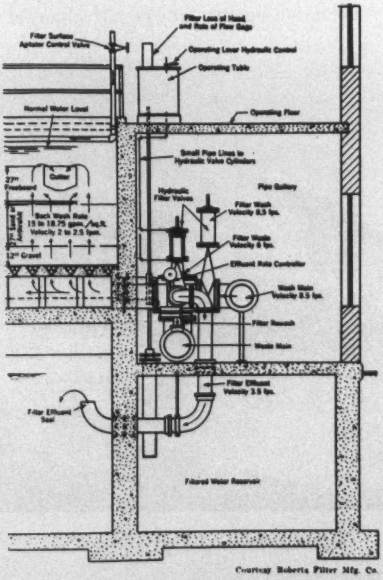
Filter Loss of Head and Rate of Flow Gage
Operating Table
Operating Floor
Small Pipe Lines to Hydraulic Valve Cylinders
Pipe Gallery
Filter Wash Velocity 8.5 fps.
Filter Wash Velocity 4 fps.
Effluent Rate Controller
Wash Water Velocity 8.5 fps.
Filter Effluent Velocity 3.5 fps.
Filtered Water Reservoir
Courtesy Roberts Filter Mfg. Co.

FIG. 18.—CROSS SECTION OF TYPICAL GRAVITY FILTER UNIT—RIGHT HALF.

TABLE 3.—COMPARATIVE LOSS OF HEAD IN FILTER STRAINER SYSTEMS

	Perforated pipe				Wheeler type			
Rate of wash (inches per min)	18	24	30	36	18	24	30	36
Loss (feet)	2.97	5.53	8.72	12.47	1.29	2.29	3.55	5.11

REFERENCE: Gale Dixon, "Hydraulics of Rapid Sand Filters", Water Works & Sewerage, April, 1935.

tribution to an area, as illustrated in Fig. 19, a view of the plant at Norwalk, Conn. Zoning Commissions would have little trouble in approving designs of this type.

Flocculation and Mixing

Exactly 25 years ago this month, a paper was delivered before this Association on the subject "Mechanical Conditioning

FIG. 19.—NORWALK, CONN., FILTER PLANT.

of Treated Waters" (20) by your present speaker. It seems appropriate at this time to bring this subject matter up-to-date with a few brief remarks. In the original paper devices currently used for mixing coagulant with raw water were discussed (Fig. 20). Also, the first Flocculator installation made at Richmond, Va., in existing basins was described. The design of this first Flocculator, shown in Fig. 21, and the installation in the first of two existing basins, produced such a marked improvement that the other basin was soon equipped.

It was also stated in this paper that mixing or flocculating

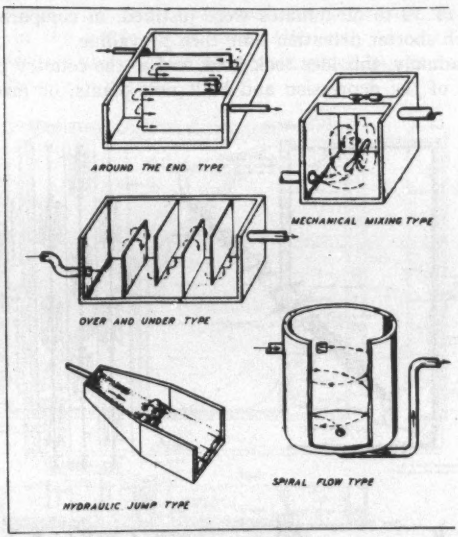

FIG. 20.—CONVENTIONAL TYPES OF MIXING UNITS, 1932.

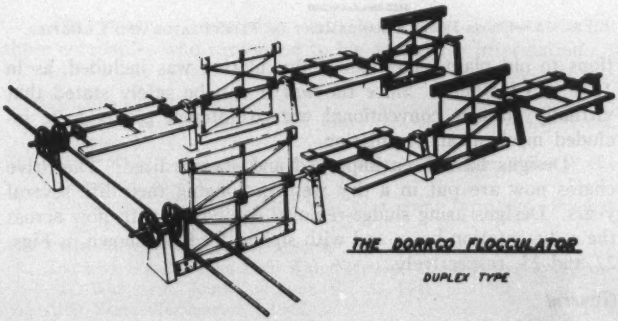

FIG. 21.—TYPICAL FLOCCULATOR, AS INSTALLED AT RICHMOND, VA.

periods of 30 to 60 minutes were justified, in comparison with the much shorter detention time then prevailing.

Gradually, this idea took hold, and as the country pulled itself out of the depression and built new plants, or made addi-

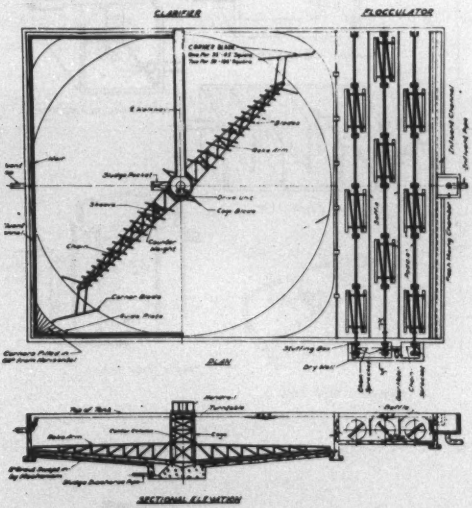

FIG. 22.—CROSS-FLOW ARRANGEMENT OF FLOCCULATOR AND CLARIFIER.

tions to old plants, mechanical flocculation was included, as in 1936 at Cincinnati. Since the war it can be safely stated that virtually all new conventional water-treatment plants have included mechanical flocculation.

Designs have been improved and standardized. The drive chains now are put in a dry well, prolonging their life several years. Designs using sludge-removal equipment with flow across the sedimentation basin and with siphon feed are shown in Figs. 22 and 23, respectively.

General

In this sketchy and somewhat disconnected discussion, an effort has been made to illustrate with a few selected examples

how equipment has been developed and improved along with progress in the water-works field. Obviously, a similar story could be written about many other items which go toward making up a water-works system.

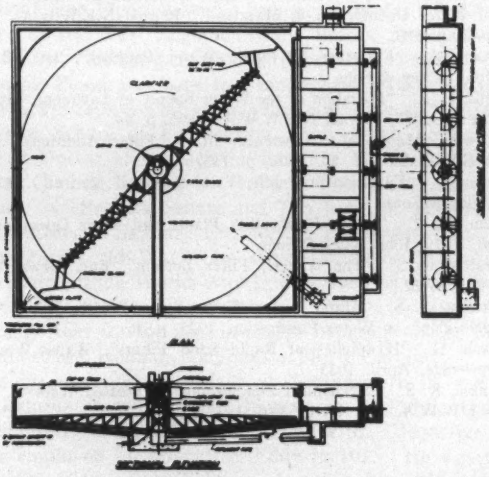

FIG. 23.—SIFEED ARRANGEMENT OF FLOCCULATOR AND CLARIFIER.

The writer acknowledges with thanks the cooperation of those companies who responded to his appeal for information.

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MEMOIR OF FRANK LEE FLOOD

Frank Lee Flood, a senior partner of Metcalf & Eddy and member of the New England Water Works Association since 1929, died at Needham, Mass., on February 14, 1958.

Frank Flood was born in Framingham, Mass., on October 24, 1897. He received his engineering education at Northeastern University School of Engineering, from which he received a degree of Doctor of Engineering in 1955. He was a member of the Beta Gamma Epsilon fraternity at Northeastern and of the honorary societies, the Senate and Tau Beta Pi. He was at one time a lecturer in Sanitary Engineering at Northeastern.

During World War I he served with the U.S. Army in France, and during World War II he served as Chief, Sanitary Section, First Service Command, U.S. Army. In 1942 he was resident partner for the firm in charge of design of the Maxton-Laurenburg and Hoffman Air Bases in North Carolina.

In his undergraduate days at Northeastern he worked as a cooperative student in the Department of Public Health of Massachusetts, and continued to work for that Department until he was employed by Metcalf & Eddy in 1925. He was made a partner in 1942. During his partnership Mr. Flood was responsible for, or was consultant on, the design of numerous sewerage and sewage treatment works. These works included such projects as the Allegheny County Sanitary Authority system at Pittsburgh, the Hyperion Sewage Treatment Plant at Los Angeles, the Nut Island Treatment Plant at Boston, and the sewage treatment facilities at Toronto, Ontario, as well as many other smaller installations.

His was an active and vigorous life spent without stint in the practice of sanitary engineering. Nevertheless, he somehow found time to participate in the affairs of the town of his domicile, of his Alma Mater, and of professional societies. He was a Mason, a life member of the Corporation of Northeastern University, a trustee of the Newton Savings Bank, and a deacon of the Needham Congregational Church, to record but a few of his public-spirited, nonprofessional services.

He was a member of the American Institute of Consulting Engineers; of the American Society of Civil Engineers; of the Boston Society of Civil Engineers, of which he was currently Vice-President; of the Federation of Sewage and Industrial Wastes Associations; and of numerous other professional societies. He was a registered professional engineer in some 14 states, the District of Columbia, and the Province of Ontario.

He is survived by his wife, Elizabeth Louise (Barnes); three sons, Frank, Jr., John W., and Roger D.; three grandchildren; two brothers, and two sisters, as well as by his parents.

Personally and professionally Frank Flood ran sixty seconds' worth of distance in every minute. He loved his work and physical activity as well. Possessed of an innate muscular coordination, he found great fun in golf, tennis and swimming. His years were filled with the joy of life, family and friends. To those who knew him and to those who worked with him he has left a most cherished memory.

E. SHERMAN CHASE

PROCEEDINGS

FEBRUARY 1958 MEETING

HOTEL STATLER, BOSTON, MASS.

THURSDAY, FEBRUARY 20, 1958

President George G. Bogren in the Chair.

The President announced the election of the following to membership in the Association:

Members:

Richard E. Johnson, Sales Representative, Red Hed Manufacturing Co., Boston, Mass.; Joseph C. Karnella, Assistant Sanitary Engineer, Division of Sanitary Engineering, Massachusetts Department of Public Health, Boston, Mass.; Donato Richardi, Superintendent, Water Department, Braintree, Mass.

Associate Member:

The Preload Company, Inc., New York, N. Y.

PRESIDENT BOGREN. I have one announcement to make. The Chairman of your Membership Committee, George W. Coffin, has asked me to announce that he would welcome any suggestions for prospective members from any of you members, so that he can follow up these leads and carry out the work of the Membership Committee. If any of you know of men who should be members of this Association, please get in touch with George W. Coffin, the Chairman of the Membership Committee.

Gentlemen, is is my sad duty to announce the passing of another member of our Association. May we stand, please, for a moment? [*The members stand.*]

It is my sad duty to announce the passing of Frank L. Flood, who died February 14, 1958. He was a partner of the firm of Metcalf & Eddy, Boston, and a member of this Association for thirty years.

A paper on "Watershed Management" was read by Norman R. Tripp, Chief, Section of Watershed Management, U.S. Forest Service, Upper Darby, Pa.

A paper on "Public Water Supplies of Connecticut and the 1957 Drought" was read by Frederick O. A. Almquist, Principal Sanitary Engineer, State Department of Health, Hartford, Conn.

A paper on "The Experiences of the City of New Britain, Connecticut, with the 1957 Drought" was read by George W. Wood, Engineer of the Board of Water Commissioners, New Britain, Conn.

MARCH 1958 MEETING

HOTEL STATLER, BOSTON, MASS.

THURSDAY, MARCH 20, 1958

President George G. Bogren in the Chair.

PRESIDENT BOGREN. Gentlemen, again it is my unpleasant duty to announce the death of a member. Lew Brigham, who was Superintendent of the Shrewsbury Water Department, passed away on March 18. May we stand for a moment in silent tribute to Mr. Brigham? [*The members stand.*]

In accordance with the constitution it is necessary at this meeting to elect a nominating committee for officers for the coming year, and the Chair at this time will recognize Mr. Ellis.

RICHARD H. ELLIS. Mr. President, in accordance with the custom of the past, I move that the last five Past Presidents, exclusive of those now serving on the Executive Committee, be named as the nominating committee, with Stanley M. Dore as Chairman.

[*The motion was duly seconded.*]

PRESIDENT BOGREN. Are there any other nominations?

E. SHERMAN CHASE. I move that the nominations be closed.

[*The motion was duly seconded and the question was put and carried.*]

PRESIDENT BOGREN. I shall instruct the Secretary to cast one ballot for the nominees mentioned by Mr. Ellis.

Now we shall hear what our Secretary has to report on business transacted today.

SECRETARY KNOX. Several new members were elected at the Executive Committee meeting this morning, and if they are present I would like to have them stand as their names are read.

Members:

Joseph C. Heney, Project Engineer, Camp, Dresser & McKee, Boston, Mass.; Arthur A. Lamelin, Superintendent, Kent

County Water Authority, West Warwick, R. I.; Edward P. Looney, Superintendent, Water Department, Belmont, Mass.; Sherwood Lovejoy, Sanitary Engineer, Bridgeport Hydraulic Co., Bridgeport, Conn.; Frank T. Smith, Jr., Project Engineer, Camp, Dresser & McKee, Boston, Mass.; Albert I. Bennett, Distribution Engineer, Bridgeport Hydraulic Co., Bridgeport, Conn.

Corporate Member:

Board of Water Commissioners, Watertown, Mass.

PRESIDENT BOGREN. Gentlemen, I wish to call to your attention the item of news regarding the scholarship on the notice of today, that in order to begin the functioning of the scholarship fund $10,000 is necessary, and that about $1,500 remains to be received. The Scholarship Committee has asked me to call to your attention that contributions would be very, very gratefully received.

A paper on "Investigations for Treating Surface Water Supply at Danvers, Massachusetts, by Micro-straining and Ozonation" was read by Elson T. Killam, President, Elson T. Killam Associates, Inc., Millburn, N. J.

A paper on "Emergency Pumping at Worcester, Massachusetts" was read by Charles B. Hardy, Superintendent, Bureau of Water, Worcester, Mass.

INDEX OF ADVERTISERS

	Page
Badger Meter Mfg. Co.	Following front cover
B-I-F Industries, Inc.	Following front cover
Bingham & Taylor Corp.	Following front cover
Brown Company	xviii
Caldwell Co., George A.	iv
Camp, Dresser & McKee	ii
Cast Iron Pipe Research Assn.	Following front cover
Cement Lined Pipe Co.	xviii
Centriline Corp.	Following front cover
Chapman Co., R. E.	ii
Coffin and Richardson	ii
Crosby, Irving B.	ii
Cummins Diesel of New England, Inc.	Following front cover
Eddy Valve Co.	xii
Eureka Pipe Co., Inc.	xiv
Fairbanks, Morse & Co.	Following front cover
Fay, Spofford & Thorndike	ii
Flexible, Inc.	xvi
Ford Meter Box Co., The	Following front cover
Gamon Div., Worthington Corp.	vi
Geraghty, Miller & Hickok	iv
Gunite Restoration Co., Inc.	ii
Haley & Ward	ii
Hays Mfg. Co.	xiii
Hazen & Sawyer	iii
Hersey Mfg. Co.	ix
Hilco Supply, Inc.	viii
Hydraulic Development Corp.	vii
Jerman, Daniel L.	iv
Johns-Manville Corp.	Following front cover
Keasbey & Mattison Co.	v
Kennedy Valve Mfg. Co.	xv
Knowles, Inc., Morris	ii
Layne-New England Co.	iii
Leadite Co.	Back cover
Leggette, Brashears & Graham	ii
Lock Joint Pipe Co.	Following front cover
Ludlow Valve Mfg. Co.	Following front cover
Maguire & Assoc., Chas. A.	iii
Maher Co., D. L.	iii
Metcalf & Eddy	ii
Mills Engineering Co., Inc.	xiv
Morris Knowles, Inc.	ii
Mueller Co.	Following front cover
National Water Main Cleaning Co.	x
Neptune Meter Co.	Following front cover
New England Pipe Cleaning Co.	xvi
Pierce-Perry Co.	iii
Pipe Founders Sales Corp.	xiv
Pirnie, Malcolm	iii
Pitometer Assoc., Inc., The	iii
Pittsburgh-Des Moines Steel Co.	Following front cover
Pittsburgh Equitable Meter Div.	Following front cover
Pollard Co., Inc., Joseph G.	Following front cover
Prescott & Sons, Inc., H. R.	xvi
Public Works Supply Co.	xviii
Rockwell Manufacturing Co.	Following front cover
Ross Valve Mfg. Co.	xvii
Smith and Norrington Engineering Corp.	iii
Smith Mfg. Co., The A. P.	Following front cover
Sterling Jr., Clarence I.	iv
Torrington Supply Co., Inc.	xviii
U. S. Cast Iron Pipe & Foundry Co.	xx
Utilities Supply Corp.	viii
Wallace & Tiernan Co., Inc.	xi
Western Waterproofing Co., Inc.	xix
Weston & Sampson	iii
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(Classified index on page xxiii)

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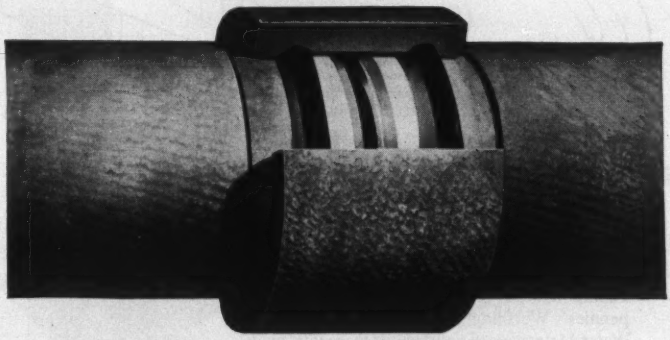

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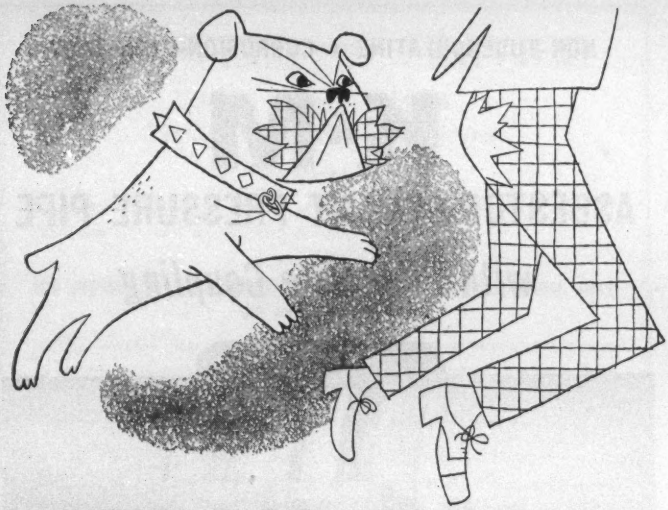

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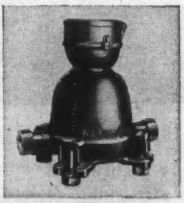

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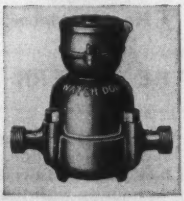

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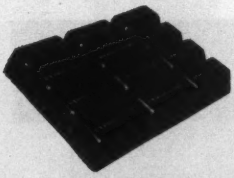

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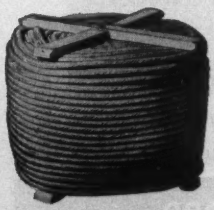

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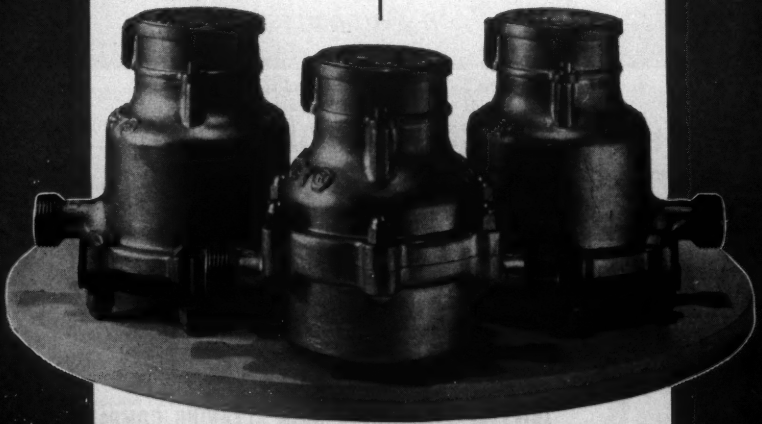

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We are proud to salute the New England Water Works Association on their 75th year of progress and achievement in the Water Works field! And we're proud for another reason — it's National's 51st year in business. For us, it means over a half-century of progress increasing efficiency, carrying capacity and pressure of water mains all over the world!

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To find out more about W & T Dry Chemical Feeders, write for bulletin S-124. Or let us know the type of feeder problem you have, so we may send publications describing the W & T equipment best suited for your job.

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Photo courtesy of Mr. W. K. Sanders, Superintendent, Water and Light Department, Morrisville, Vermont

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Eddy Hydrants and Valves meet all AWWA standards and are available to fit any existing or planned installation.

Send today for full data on the complete line of Eddy Valves, Hydrants and other waterworks' necessities. No obligation.

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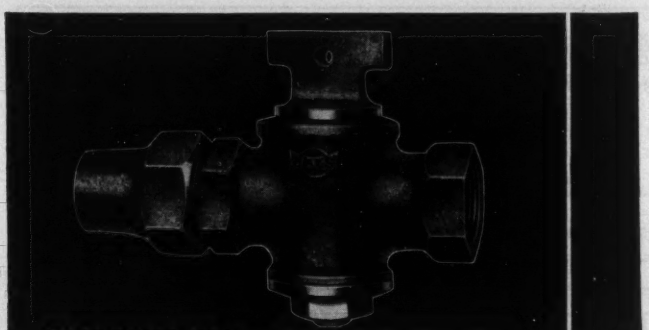

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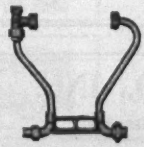
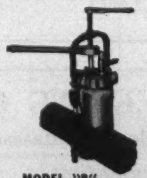
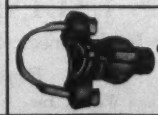


COPPER METER SETTERS



MODEL "B" TAPPING MACHINE

CORPORATION STOP



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KENNEDY VALVE has a complete line of A.W.W.A. Standard Gate Valves . . .

. . . that conform to A.W.W.A. specifications in all respects

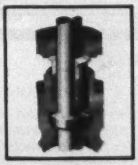
FIG. 56
- Inside Screw
- Non-Rising Stem
- Parallel Seats
- Bell Ends

FIG. 571X
- Inside Screw
- Non-Rising Stem
- Parallel Seats
- Mechanical Joint Ends

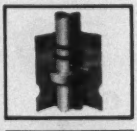
FIG. 561
- Inside Screw
- Non-Rising Stem
- Parallel Seats
- Flanged Ends

FIG. 566
- Outside-Screw-and-Yoke
- Rising Stem
- Parallel Seats
- Flanged Ends

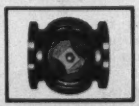
Construction features . . .



Conventional stuffing box
with adjustable gland has ample space for packing that conforms to Federal specification HH-P-106c. The bottom face of the stuffing box flange is faced smooth to form bearing surface for stem thrust collar.



O-Ring seals
once installed no adjustment of any kind is required. The top O-Ring is the dirt seal and the bottom O-Ring is the pressure seal.



Operating nut
is Higher Strength Cast Iron. The base flange, with arrow indicating direction to open, is shaped to permit access from ground surface to adjust gland nuts with an extension socket wrench.

KENNEDY A.W.W.A. Standard gate valves are designed specifically for use in water works systems. Conforming to A.W.W.A. Specifications, in several particulars these valves exceed these standards of strength and refinements of design.

While A.W.W.A. Specifications cover only bell end and flanged end non-rising stem valves, the KENNEDY line also includes outside-screw-and-yoke valves and a wide variety of pipe connections including: Bell Ends, Flanged Ends, Mechanical Joint Ends, Universal Pipe Ends, Asbestos Cement Pipe Ends, Screwed Ends, Ring-Tite Pipe Ends and Spigot Ends.

In addition to standard features, KENNEDY A.W.W.A. Valves have reduction gearing, gear cases, by-passes, indicators and rollers, tracks and scrapers available on 16" and larger sizes. Gearing is always furnished on 30" and larger valves.

KENNEDY VALVE MFG. CO.
ELMIRA, NEW YORK
VALVES
FIRE HYDRANTS

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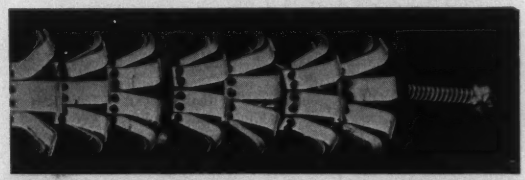

FLEXIBLE'S PATENTED PRESSURE TOOL with its two counter rotating heads, saw tooth head and cutting and scraping heads removes in minutes the accumulation of years.

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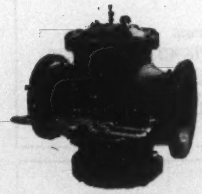


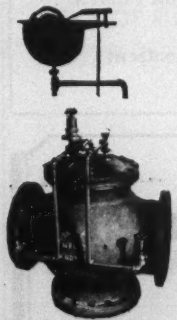
Controls elevation of water in tanks, basins and reservoirs

ALTITUDE VALVE
1. Single Acting
2. Double Acting

Maintains desired discharge regardless of change in rate of flow pressure

REDUCING VALVE

Regulates pressures in gravity and pump systems; between reservoirs and zones of different pressures, etc.



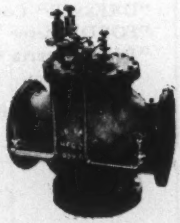
Maintains levels in tank, reservoir or basin

1. As direct acting.

2. Pilot operated and with float traveling between two stops, for upper and lower limit of water elevation.

FLOAT VALVE

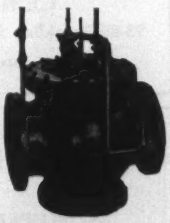
A self contained unit, with controls three or more automatic



COMBINATION VALVE

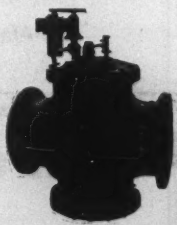
Combination automatic control both directions through the valve.

Maintains safe operating pressures for conduits, distribution and pump discharge



SURGE-RELIEF VALVE

Electric remote control—solenoid or motor can be furnished



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U.S. cast iron PIPE FOR WATER, SEWERAGE AND

let go!

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General Office: Birmingham 2, Alabama

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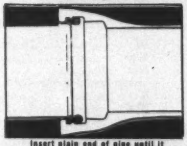
INDUSTRIAL SERVICE CAST IRON

TYTON

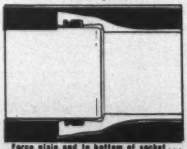
ONLY FOUR SIMPLE ACTIONS

Insert gasket with groove over bead in gasket seat

Wipe a film of special lubricant over inside of gasket

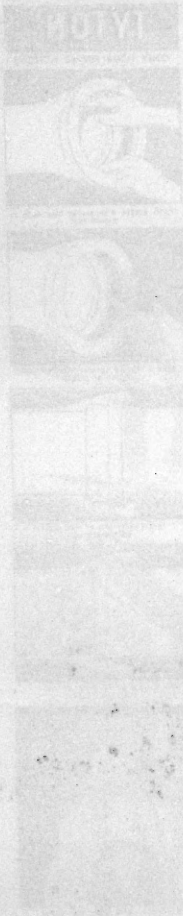


Insert plain end of pipe until it contacts gasket



Force plain end to bottom of socket... the job's done!

12" Tyton Joint pipe for water line in Florida



CLASSIFIED DIRECTORY OF ADVERTISEMENTS

ASBESTOS-CEMENT PIPE.
Johns-Manville Corp. ..... Following front cover
Keasbey & Mattison Company v

BRASS GOODS.
Caldwell Co., George A. iv
Eureka Cement Lined Pipe Co. xiv
Hilco Supply, Inc. viii
Mueller Co. ..... Following front cover
Pierce-Perry Co. iii
Torrington Supply Co., Inc. xvi
Utilities Supply Corp. viii

BROKEN PIPE REPAIR CLAMPS.
D. L. Jerman iv

CALKING MACHINERY AND TOOLS.
Hydraulic Development Corp. vii
Mueller Co. ..... Following front cover

CAST IRON PIPE. (See Pipe, Cast Iron.)

CEMENT LINED PIPE. (See Pipe, Cement Lined.)

CHEMICAL FEED APPARATUS.
B-I-F Industries ..... Following front cover
Wallace & Tiernan Co., Inc. xi

CHLORINATORS.
B-I-F Industries ..... Following front cover
Wallace & Tiernan Co., Inc. xi

CLAMPS.
D. L. Jerman iv

CLARIFIERS.
Mills Engineering Co., Inc. xiv

CLEANING WATER MAINS.
Flexible Pipe Cleaning Co. xviii
National Water Main Cleaning Co. x

COCKS, CURBS AND CORPORATIONS.
Caldwell Co., George A. iv
Eureka Cement Lined Pipe Co. xiv
Hays Mfg. Co. xiii
Mueller Co. ..... Following front cover
Pierce-Perry Co. iii
Utilities Supply Corp. viii

CONCRETE PIPE. (See Pipe, Concrete.)

CONTRACTORS' EQUIPMENT.
Hydraulic Development Corp. vii

CONTRACTORS.
Layne-New York Co., Inc. iii
Maher, D. L. Co. iii
White Construction Co., R. H. xiv

COUPLINGS, FLEXIBLE PIPE.
Caldwell Co., George A. iv
Public Works Supply Company xviii

CURB BOXES.
Bingham & Taylor Corp. ..... Following front cover
Caldwell Co., George A. iv
Eureka Cement Lined Pipe Co. xiv
Hays Mfg. Co. xiii
Hilco Supply, Inc. viii
Mueller Co. ..... Following front cover
Pierce-Perry Co. iii
H. R. Prescott & Sons, Inc. xvi
Public Works Supply Company xviii
Utilities Supply Corp. viii

DIAPHRAGMS, PUMPS.
B-I-F Industries, Inc. ..... Following front cover
Joseph G. Pollard Co. ..... Following front cover

EJECTOR, PNEUMATIC.
Mills Engineering Co., Inc. xiv

ENGINEERS.
Camp, Dresser & McKee ii
Coffin & Richardson ii
Crosby, Irving B. ii
Fay, Spofford and Thorndike ii
Haley and Ward ii
Hazen and Sawyer iii
Knowles Morris, Inc. ii
Leggette, Brashears & Graham ii
Maguire & Associates, Charles A. iii
Metcalf and Eddy ii
Pirnie Engineers, Malcolm iii
Pitometer Associates, Inc., The iii
Smith and Norrington iii
Weston and Sampson iii
Whitman and Howard iii

ENGINES. (See Pumps and Pumping Engines.)

EQUIPMENT. (See Contractors' Equipment.)

CLASSIFIED DIRECTORY OF ADVERTISEMENTS *(Continued)*

FEED WATER FILTERS.
B-I-F Industries, Inc. ..... Following front cover
Ross Valve Mfg. Co., Inc. xvii
FILTRATION PLANT EQUIPMENT.
B-I-F Industries ..... Following front cover
Mills Engineering Co., Inc. xiv
FLAP VALVES.
Eddy Valve Co. xii
FLEXIBLE JOINTS.
U. S. Pipe and Foundry Co. xx
FURNACES.
Hilco Supply, Inc. viii
Hydraulic Development Corp. vii
Leadite Co., The ..... Back cover
Mueller Co. ..... Following front cover
Pollard Co., Joseph G. ..... Following front cover
H. R. Prescott & Sons, Inc. xvi
Public Works Supply Company xviii
Utilities Supply Corp. viii
GATE VALVES. (See Valves.)
GEARS.
Mills Engineering Co., Inc. xiv
GENERATOR SETS
Cummins Diesel of New England, Inc. ..... Following front cover
GUNITE CONSTRUCTION.
Gunite-Restoration Co., Inc. ii
HOSE, SUCTION AND CONDUCTION.
H. R. Prescott & Sons, Inc. xvi
HYDRANTS, FIRE.
Caldwell Co., George A. iv
Eddy Valve Co. xii
Hilco Supply, Inc. viii
Kennedy Valve Mfg. Co. xv
Ludlow Valve Mfg. Co. ..... Following front cover
Mueller Co. ..... Following front cover
H. R. Prescott & Sons, Inc. xvi
Public Works Supply Company xviii
Smith Mfg. Co., The A. P. ..... Following front cover
Utilities Supply Corp. viii
Wood, R. D., Co. ..... Following front cover
HYDRANTS, PUMPS.
Hilco Supply, Inc. viii
Joseph G. Pollard Co. ..... Following front cover
H. R. Prescott & Sons, Inc. xvi
LEAD PIPE. (See Pipe, Lead.)
LIQUID CHLORINE.
Brown Co. xviii
METERS, OIL AND WATER.
Badger Meter Mfg. Co. ..... Following front cover
B-I-F Industries ..... Following front cover
Gamon Meter Div., Worthington Corp. vi
Hersey Mfg. Co. ix
Neptune Meter Co. ..... Following front cover
Pipe Founders Sales Corp. xiv
Pittsburgh Equitable Meter Div. ..... Following front cover
METER COUPLINGS.
Badger Meter Mfg. Co. ..... Following front cover
Caldwell Co., George A. iv
Ford Meter Box Co. ..... Following front cover
Gamon Meter Div., Worthington Corp. vi
Hays Mfg. Co. xiii
Hersey Mfg. Co. ix
Mueller Co. ..... Following front cover
Neptune Meter Co. ..... Following front cover
Public Works Supply Company xviii
METERS (Venturi Type.)
B-I-F Industries ..... Following front cover
METER BOXES.
Bingham & Taylor Corp. ..... Following front cover
Ford Meter Box Co. ..... Following front cover
Mueller Co. ..... Following front cover
Public Works Supply Company xviii
METER TESTERS.
Badger Meter Mfg. Co. ..... Following front cover
Ford Meter Box Co. ..... Following front cover
Mueller Co. ..... Following front cover
Neptune Meter Co. ..... Following front cover
Public Works Supply Company xviii
OIL ENGINES.
Fairbanks, Morse & Co. ..... Following front cover
PIPE, ASBESTOS-CEMENT.
Johns-Manville Corp. ..... Following front cover
Keasbey & Mattison Company v

CLASSIFIED DIRECTORY OF ADVERTISEMENTS *(Continued)*

PIPE, BRASS.
Caldwell Co., George A. iv
Hilco Supply, Inc. viii
Pierce-Perry Co. iii
H. R. Prescott & Sons, Inc. xvi
Torrington Supply Co., Inc. xvi
Utilities Supply Corp. viii

PIPE, CAST IRON (and Fittings.)
B-I-F Industries ..... Following front cover
Bingham & Taylor Corp. ..... Following front cover
Cast Iron Pipe Research Association xxiii
Hilco Supply, Inc. viii
Pipe Founders Sales Corp. xiv
H. R. Prescott & Sons, Inc. xvi
U. S. Pipe and Foundry Co. xx
Utilities Supply Corp. viii
Wood, R. D., Co. ..... Following front cover

PIPE, CEMENT LINED.
Cast Iron Pipe Research Association ..... Following front cover
Cement Lined Pipe Co. xviii
Eureka Cement Lined Pipe Co. xiv
Pipe Founders Sales Corp. xiv
U. S. Pipe and Foundry Co. xx
Utilities Supply Corp. viii

PIPE CLEANING
New England Pipe Cleaning Co. xvi

PIPE, COATING AND LININGS.
Centriline Corp. ..... Following front cover

PIPE, CONCRETE.
Lock Joint Pipe Co. ..... Facing front cover

PIPE CUTTING MACHINES.
Caldwell Co., George A. iv
Pollard Co., Joseph G. ..... Following front cover
Smith Mfg. Co., The A. P. ..... Following front cover

PIPE JOINTING MATERIAL.
Caldwell Co., George A. iv
Hilco Supply, Inc. viii
Hydraulic Development Corp. vii
Leadite Co., The ..... Back cover
Utilities Supply Corp. viii

PIPE, LEAD.
Pierce-Perry Co. iii

PIPE LINING.
Cement Lined Pipe Co. xviii
Centriline Corp. ..... Following front cover

PIPE, PRESTRESSED CONCRETE.
Lock Joint Pipe Co. ..... Facing front cover

PIPE REPAIR CLAMPS.
D. L. Jerman iv

PIPE, WROUGHT IRON AND STEEL.
Pierce-Perry Co. iii
Torrington Supply Co., Inc. xvi

PITOMETERS.
Pitometer Associates, Inc., The iii

PLUG VALVES.
Eddy Valve Co. xii
Hays Mfg. Co. xiii
Mueller Co. ..... Following front cover
Pittsburgh Equitable Meter Div. ..... Following front cover

PORTABLE AIR COMPRESSORS. (See Air Compressors.)

PRESSURE REGULATORS.
Hilco Supply, Inc. viii
Mueller Co. ..... Following front cover
Pittsburgh Equitable Meter Div. ..... Following front cover
H. R. Prescott & Sons, Inc. xvi
Ross Valve Mfg. Co., Inc. xvii

PROVERS, WATER.
Badger Meter Mfg. Co. ..... Following front cover
Ford Meter Box Co. ..... Following front cover

PUMPS AND PUMPING MACHINES.
Cummins Diesel of New England, Inc. ..... Following front cover
Fairbanks, Morse & Co. ..... Following front cover
Layne-New England Co. iii
Hilco Supply, Inc. viii
Maher Co., D. L. iii
Mills Engineering Co., Inc. xiv
Joseph G. Pollard Co. ..... Following front cover
H. R. Prescott & Sons, Inc. xvi
Ross Valve Mfg. Co., Inc. xvii
White Construction Co., R. H. xiv

RATE CONTROLLERS AND GAUGES.
Badger Meter Mfg. Co. ..... Following front cover
B-I-F Industries ..... Following front cover

REDUCERS, SPEED.
Mills Engineering Co., Inc. xiv

REPAIR CLAMPS.
D. L. Jerman iv

CLASSIFIED DIRECTORY OF ADVERTISEMENTS *(Continued)*

SHEAR GATES.
Eddy Valve Co. xii
Mueller Co. ..... Following front cover
SLEEVES AND VALVE TAPPINGS.
Caldwell Co., George A. iv
Eddy Valve Co. xii
Hilco Supply, Inc. viii
Ludlow Valve Mfg. Co. ..... Following front cover
Mueller Co. ..... Following front cover
H. R. Prescott & Sons, Inc. xvi
Public Works Supply Company xviii
Smith Mfg. Co., The A. P. ..... Following front cover
Utilities Supply Corp. viii
STEEL PLATE WORK.
Pittsburgh-Des Moines Steel Co. ..... Following front cover
STRAINERS.
Mills Engineering Co., Inc. xiv
SUPPLIES AND TOOLS.
Caldwell Co., George A. iv
Hilco Supply, Inc. viii
Hydraulic Development Corp. vii
Leadite Co., The ..... Back cover
Mueller Co. ..... Following front cover
Pierce-Perry Co. iii
Pollard Co., Joseph G. ..... Following front cover
H. R. Prescott & Sons, Inc. xvi
Public Works Supply Company xviii
TANKS, STEEL.
Pittsburgh-Des Moines Steel Co. ..... Following front cover
TAPPING MACHINES.
Caldwell Co., George A. iv
Hays Mfg. Co. xiii
Mueller Co. ..... Following front cover
Smith Mfg. Co., The A. P. ..... Following front cover
TAPPING SLEEVES. (See Sleeves and Valves, Tappings.)
VALVE BOXES.
Bingham & Taylor Corp. ..... Following front cover
Caldwell Co., George A. iv
Eddy Valve Co. xii
Hilco Supply, Inc. viii
Kennedy Valve Mfg. Co. xv
Mueller Co. ..... Following front cover
Pierce-Perry Co. iii
Pipe Founders Sales Corp. xiv
H. R. Prescott & Sons, Inc. xvi
Public Works Supply Company xviii
Smith Mfg. Co., The A. P. ..... Following front cover
Utilities Supply Corp. viii
Wood, R. D., Co. ..... Following front cover
VALVE AND GATE GENERATORS.
Mills Engineering Co., Inc. xiv
VALVE INSERTING MACHINES.
Mueller Co. ..... Following front cover
Smith Mfg. Co., The A. P. ..... Following front cover
VALVES, CHLORINE.
Wallace & Tiernan Co., Inc. xi
VALVES, GATE.
Caldwell Co., George A. iv
Eddy Valve Co. xii
Hilco Supply, Inc. viii
Kennedy Valve Mfg. Co. xv
Ludlow Valve Mfg. Co. ..... Following front cover
Mueller Co. ..... Following front cover
Pierce-Perry Co. iii
H. R. Prescott & Sons, Inc. xvi
Public Works Supply Company xviii
Smith Mfg. Co., The A. P. ..... Following front cover
Torrington Supply Co., Inc. xvi
Utilities Supply Corp. viii
Wood, R. D., Co. ..... Following front cover
VALVES, REGULATING.
Mueller Co. ..... Following front cover
Ross Valve Mfg. Co., Inc. xvii
WASH FOUNTAINS.
Mills Engineering Co., Inc. xiv
WATER-PROOFING.
Gunite Restoration Co., Inc. ii
Western Waterproofing Co., Inc. xix
WATER WASTE DETECTION.
Pitometer Associates, Inc., The iii
WELLS, GRAVEL, FILTER AND DRIVEN.
Layne-New England Co. iii
Maher Co., D. J. iii
WROUGHT IRON PIPE. (See Pipe, Wrought Iron and Steel.)

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